

# LLOYDIA

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### Brazilian Chytrids. VIII. Additional Parasites of Rotifers and Nematodes

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In a previous contribution relating to aquatic fungi of the Amazon Valley in Brazil, the author (1944) described three new *Lagenidium* species which parasitize the eggs, embryos and adults of rotifers. Species of this genus are characterized by biflagellate zoospores and therefore belong to the family Lagenidiaceae. Since that time several additional fungous parasites of the same hosts and nematodes have been found in the soil and water samples collected in Brazil in 1943. The latter group of parasites, on the other hand, have posteriorly uniflagellate zoospores and, accordingly, relate to the order Chytridiales.

The first two chytrids are internal holocarpic parasites of rotifer eggs and adults and belong in the genus *Olpidium*. However, their identity and relationship to other known *Olpidium* parasites of rotifers are not certain because the latter group of species are poorly known and have not been fully described. Up to the present time, approximately twelve species of this genus have been described as infecting nematodes, rotifers, monads and other microscopic animals. Of these only two species, *O. gregarium* and *O. macrosporum*, and one variety, *O. entophytum* var. *intermedium*, have been reported as parasites of rotifers. *Olpidium gregarium* (Nowakowski, 1876) Schroeter appears to be the most common and widely distributed and has been reported from Germany, England, Denmark, India, Japan and the U.S.A. It is characterized by sporangia with short broad exit tubes, spherical,  $2.5-3\mu$ , zoospores which contain a conspicuous hyaline refractive globule, and by large brown resting spores. *Olpidium macrosporum*, on the other hand, has been reported only once and is a very doubtful species. It is distinguishable by unusually large, ellipsoid,  $6 \times 10\mu$ , zoospores which are optically homogeneous and lack refractive globules, and by sporangia with greatly elongate tortuous exit tubes. Nowakowski (1876) did not observe flagella on the zoospores and described the appearance of the protoplasm and the method of cleavage as being similar to

those of saprolegniaceous fungi. It is quite probable, therefore, that this species does not relate to *Olpidium* at all. *Olpidium entophyllum* var. *intermedium* Constantineanu (1901) is so little known that no definite conclusion can be drawn about its relationships. Constantineanu found neither zoospores nor resting spores, and the long undulating exit tube which he described resembles that of *O. macrosporum*. It is not improbable therefore, that his fungus may relate to the latter species.

The *Olpidium* parasites found by the author in Brazil differ primarily from those noted above by the size, shape and appearance of the zoospores and resting spores. The more commonly occurring one, illustrated in figs. 1 to 13 and 16 to 18, has spherical  $3.5\text{--}4.5\mu$ , zoospores which are slightly larger than those of *O. gregarium*, have an unusually long,  $38\text{--}45\mu$ , flagellum, and lack a conspicuous refractive globule. Instead, they contain numerous minute granules which are not very refringent. The exit tubes of the sporangia, however, are relatively broad and short like those of *O. gregarium*. On the other hand, its resting spores are hyaline in contrast to the brown color of the spores of *O. gregarium*. The presence or absence of a conspicuous refractive globule in zoospore are specific characters which seldom vary in chytrids, and primarily for this reason the writer does not believe that his species is identical to *O. gregarium* or to any of the other known *Olpidium* parasites of rotifers. In the lack of a refringent globule and the presence of numerous minute granules, the zoospores of the author's species resemble those of *O. Vampyrellae* (Scherffel, 1926), but the latter's zoospores are slightly smaller in size and oval in shape and have a shorter flagellum. Accordingly the Brazilian parasite is regarded as a new species and described below.

The second *Olpidium* species, illustrated in figs. 19 to 34, parasitizes the eggs and adults of *Monostyla* and *Distyla*, and is characterized by larger, oblong,  $3\text{--}3.5 \times 6\text{--}7\mu$ , zoospores, which contain one or two small elongate lateral refractive globules and have a relatively short,  $12\text{--}14\mu$ , flagellum, and by hyaline, oval to spherical resting spores. By these characters it differs from the other known parasites of rotifers and is therefore diagnosed as a new species and described below.

In addition to these species several monocentric rhizidiaceous species and one polycentric chytrid have been found in rotifers and nematodes in Brazil. Three of the monocentric species, *Rhizophyidium gibbosum*, *R. zoophthorum*, and *Endochytrium operculatum*, and the polycentric member, *Catenariu Anguillulae*,<sup>1</sup> are fairly well known and have been reported several times from various parts of the world. A fourth monocentric species was found on the eggs and adults of nematodes which relates to the genus *Phlyctochytrium* and appears to be new. It is the only known species of this

<sup>1</sup> Since this paper went to press, Couch (1945, Mycologia 37: 187) has established a new family for this species and transferred it to the Blastocladales.



genus which parasitizes microscopic animals, and inasmuch as the author has been unable to transfer it to algae and other hosts he regards it as a new species.

***Olpidium granulatum*, sp. nov.**

Sporangiis hyalinis, laevibus, ovalibus,  $7-26 \times 12-44\mu$ , subsphaericis  $8-50\mu$  diam., in unum brevem, latum,  $3.5-5 \times 6-10\mu$  tubulum exeuntibus, Zoosporis sphaericis,  $3.5-4.5\mu$ , dense minuteque granulosi; flagello  $38-45\mu$  longo. Sporis perdurantibus, hyalinis, laevibus sphaericis vel ovalibus,  $14-22\mu$  diam. Germinatione ignota.

Sporangia, hyaline, smooth, oval, ellipsoid,  $7-26 \times 12-44\mu$ , usually numerous, up to 16 in a cell, subspherical,  $8-50\mu$  diam., with one,  $3.5-5\mu$  wide by  $6-10\mu$  long, exit tube which usually does not extend far beyond the surface of the host cell. Emerged zoospores forming a globular mass at the exit orifice before dispersing; spherical,  $3.5-4.5\mu$ , with numerous minute granules and a  $38-45\mu$  long flagellum. Resting spores hyaline, smooth, spherical or oval,  $14-22\mu$ ; germination unknown.

Parasitic in rotifer eggs, San Carlos, Matto Grosso, Brazil.

This species developed very quickly and abundantly in watered soil cultures and soon attained epidemic proportions in the eggs of *Distyla* sp. In one mount measuring 24 mm. square, four hundred and thirty-two infected eggs were found. However, the epidemic of infection began to subside within three weeks and after two months no evidence of the parasite was to be found. As in *O. gregarium* the sporangia are usually quite numerous (fig. 1) and as many as sixteen may often occur in one egg. On the other hand, a single large sporangium which almost fills the entire egg is not an uncommon occurrence in this species. The size and shape of the sporangia are usually correlated with the number present. When numerous sporangia are present they are usually small, crowded and even somewhat angular in shape, whereas, when only one to two occur, they almost fill the egg and may be oval to subspherical in shape.

Infection of the egg is readily observable, particularly when the content of the egg is contracted as in fig. 2. The zoospore comes to rest on the surface, round up, and after a dormant period of  $1\frac{1}{2}$  to 3 hours forms a germ tube which penetrates the wall. In cases where the host protoplasm is contracted and enveloped by a membrane (fig. 2) the germ tube may become relatively long. After it has entered the host its tip apparently deliquesces and the spore plasma slowly flows into the egg, leaving the empty spore case behind. Fig. 3 shows an infected egg with four small parasites within and a fifth one in the process of entering. In these early stages no well-defined walls are visible around the parasites, but the fact that the protoplasts of host and parasite are immiscible indicates that some type of delimiting membrane is present around the latter. No marked antagonism between the two protoplasts is visible at first, but within a short time the host pro-



toplasm begins to retract from the wall and becomes more and more vacuolate (fig. 3). As the parasites grow in size the host protoplasm aggregates around them and is gradually absorbed, so that very little is present in the egg but sporangia by the time the latter are mature.

In the young stages the protoplasm of the parasite appears to be very hydrated or watery with a few suspended discrete bodies. Well-defined vacuoles soon develop into the cytoplasm (figs. 5, 6) which usually fuse later (fig. 7) to form one or more larger central ones. This phase is followed by progressive cleavage (figs. 8, 9) and maturation of the cleavage segments. At maturity the tip of the relatively short exit tube deliquesces and the zoospores emerge singly and in quick succession (fig. 1-A). They form a globular mass at the orifice and are embedded in a slimy substance which apparently dissolves and disperses in a very short time, for within a minute after emerging the zoospores begin to separate. By the time a minute and a half has elapsed, they begin to shake violently and within two minutes they swim away. The first swimming movement is quite uneven, and the zoospore appears to shake and vibrate as it moves along. Later the movement becomes more regularly darting or hopping.

As was noted earlier the zoospores lack a conspicuous refractive globule and contain instead numerous minute granules which are more or less evenly distributed (figs. 10, 12). They are further distinguishable from those of *O. gregarium* by the possession of an unusually long flagellum. With the view of emphasizing these differences more objectively, I have presented in figs. 14 and 15 zoospores of *O. gregarium* as they were drawn by Nowakowski (1876) and Butler (1907). The zoospores of *O. granulatum* may often become slightly amoeboid in shape (fig. 12) and creep around with the long flagellum trailing behind. The motile period lasts from twenty-five to seventy minutes after which the zoospores come to rest and round up (fig. 13). Some of them may remain in this state for several hours and often have the appearance of minute cystospores. Those which fail to reach the host eventually disintegrate. Occasionally, cleavage in the sporangia is incomplete or unequal with the result that large zoospores are formed. Fig. 11 shows an unusually large,  $11\mu$  in diam., abnormal zoospore with six long flagella.

The resting spores of *O. granulatum* are hyaline, smooth, oval to spherical in shape (figs. 16-18),  $14-25\mu$ , and lie in thin-walled hyaline vesicles which vary from 22 to  $33\mu$  in diameter. The content of the spores is at first coarsely granular and refractive, but as time goes on the refractive material accumulates in the form of large globules (figs. 17, 18). Germination of the spores has not been observed. Similar spores were found by Butler (1907) and Sparrow (1936) in *O. gregarium*, but these were brown instead of hyaline in color. Butler believed that the surrounding vesicles were the remnants of the cleavage segments of the egg which had become





PLATE I. Figs. 1-18.—*Olpidium granulatum*. 1. Rotifer egg with eight sporangia of parasite. 2. Infection of rotifer egg. 3. Egg with four minute parasites; a fifth one in the process of entering; empty spore cases attached to surface of egg. 4-9. Successive developmental stages of thallus and sporangium. 10-13. Spherical abnormal multiflagellate, amoeboid, and quiescent zoospores, respectively. 14, 15. Zoospores of *O. gregarium* after Nowakowski (1876) and Butler (1907), respectively. 16. Rotifer egg with two sporangia and two resting spores. 17, 18. Resting spores in vesicles. Figs. 19-34.—*O. rotiferum*. 19. Adult rotifer with ten parasites. 20-22 A. Infection of egg and successive developmental stages of a thallus. 23-27. Developmental stages, cleavage, internal swarming of zoospores, deliquescence of exit papilla, and discharge of zoospores from a pyriform sporangium. 28, 29. Oblong zoospores with a dense central region and two refractive globules. 30, 31. Zoospores near end of motile period; dense nuclear cap around nucleus. 32-34. Stages in resting spore formation.

infected. Sparrow (1943) concurred with this belief, but the present writer is not certain that this is true of the vesicles in *O. granulatum*.

***Olpidium rotiferum*, sp. nov.**

Sporangiis hyalinis, laevibus, pyriformibus,  $12-40 \times 20-70\mu$ , ovalibus,  $10-20 \times 15-35\mu$ , subsphaericis,  $15-40\mu$ , in unum brevem latum,  $4-6 \times 5-12\mu$ , tubulum exeuntibus. Zoosporis oblongis,  $3-3.5 \times 6.5-7\mu$ ; flagello  $12-14\mu$  longo. Sporis perdurantibus, hyalinis, laevibus, ovalibus,  $12-14 \times 15-17\mu$ , sphaericis,  $10-15\mu$ . Germinatione ignota.

Sporangia gregarious, up to 15 in a cell, hyaline, smooth, predominantly pyriform,  $12-40 \times 20-70\mu$ , oval,  $10-20 \times 15-35\mu$ , subspherical  $15-30\mu$ , with one short broad,  $4-6 \times 5-12\mu$  exit tube. Zoospores swarming in sporangium before emerging; later forming a globular mass at exit orifice; oblong,  $3-3.5 \times 6.5-7\mu$ , with one or two small lateral, elongate refractive bodies; flagellum  $12-14\mu$  long. Resting spores hyaline, smooth, oval,  $12-14 \times 15-17\mu$ , spherical,  $10-15\mu$ ; germination unknown.

This species parasitizes eggs and adults of rotifers but occurs most commonly in the adult bodies. Like *O. granulatum* it attained epidemic proportions for a short time but disappeared from the cultures within two months. In severe cases of infection (fig. 19) the rotifer body may become filled with sporangia, and in a few instances as many as 15 parasites were found in one host. Infection of mature rotifers was not observed but in the case of eggs the method is fundamentally the same as was described for *O. granulatum*. The zoospore comes to rest on the host cell and develops a penetration tube through which the protoplasm flows into the egg (fig. 20). The mature rotifer does not appear to suffer any ill effects at first from the presence of the parasite and may continue to feed normally for a time. However, as the parasites increase in size it becomes sluggish and ceases feeding and by the time the parasites are half grown it is usually dead. The content of the rotifer body is gradually absorbed so that when the sporangia are mature scarcely anything but the shell remains. The changes produced in the eggs are much the same as those induced by *O. granulatum*.

Successive developmental stages of a thallus are shown in figs. 20 to 22-A and 23 to 27, which indicate that *O. rotiferum* develops in the same manner as the previous species. However, just before the exit tube deliquesces the zoospores begin to swarm in the sporangium (fig. 25). As is indicated by the arrows, the whole mass rotates for ten to ninety seconds in much the same fashion as Miss Waterhouse (1940) and the author (1942) have described for *Rozellopsis* and *Rozella*. As the tip of the exit tube deliquesces a small globular mass of hyaline slime exudes, (fig. 26) after which the zoospores swarm out. The first spores to emerge form a globular or irregular mass at the exist orifice, but they disperse before most



of the spores are discharged. Those within the sporangium continue to swarm, emerge singly and dart directly away. In large sporangia complete discharge of the zoospores may require up to ninety seconds.

As was noted elsewhere the zoospores are oblong to elongate in shape and have a comparatively short flagellum (figs. 28-31). Near the base and slightly towards the side lies one or two small oblong refractive bodies which may change in position as the zoospore swims or creeps about. The lower central portion of the spore is occupied by a globular denser mass which appears to be the nucleus. It becomes more optically heterogeneous and well-defined as the zoospore comes to rest, and in many cases observed it was surrounded at the upper end by a denser layer which resembles the nuclear cap of other simple fungi. Near the end of the motile period, which lasts from forty to seventy-five minutes, the zoospores become pyriform in shape (fig. 30) with a tapering anterior end, and by the time they have come to rest they are usually spherical (fig. 31).

The resting spores usually developed in abundance as the cultures became old. As was described in the diagnosis above, they are hyaline, smooth, oval or spherical in shape with a coarsely granular and refractive content (figs. 32-34). As they mature the refractive material usually accumulates in the form of numerous small globules. Like those of *O. gregarium* and *O. granulatum* the resting spores of *O. rotiferum* lie in hyaline vesicles, but in this species the vesicles are the walls of its own partly empty and unopened sporangia or thalli instead of cleavage segments of the host. The durable spores are formed by the contraction and encystment of the protoplasm in thalli or incipient sporangia in the same fashion described by Buckley and Clapham (1929) and the author (1944) for *Catenaria Anguillulae* and *Lagenidium parthenosporum*, respectively. Numerous successive stages of this process were observed which left no doubt about the origin, identity and nature of the vesicles. Figures 33 and 34 are particularly significant, because they show resting spores in incipient sporangia which had developed to the stage of exit tubes before their protoplasm contracted and encysted. The discovery that these vesicles relate to the fungus instead of the host suggests that those described above for *O. granulatum* also may be of the same nature, and for this reason the author is reluctant to regard them as infected and modified cleavage segments of the host. The walls of the sporangia, and resting spores of *O. rotiferum* and *O. granulatum* show no positive cellulose reaction when tested with chloriodide of zinc.

✓ **Phlyctochytrium nematodeae, sp. nov.**

Sporangiis extramatrixlibus, hyalinis, laevibus, sphaericis, 16-24 $\mu$ , ovalibus, 15-18 $\times$ 19-22 $\mu$ , rare urceolatis, 10-16 $\times$ 18-26 $\mu$ , uno aut multis papillis instructis. Zoosporis ovalibus, 2.5-3 $\mu$ , unguiculatis; flagello 12 $\mu$



longo. Sporis perdurantibus, extramatricibus, hyalinis, laevibus, ovalibus sphaericis, 7-10 $\mu$ . Germinatione ignota.

Sporangia usually numerous, extramatrical, hyaline, smooth, spherical, 16-24 $\mu$ , oval, 15-18 $\times$ 19-22 $\mu$ , rarely slightly urceolate, 10-16 $\times$ 18-26 $\mu$ , with one to five low exit papillae. Apophysis oval, subspherical, 4-7 $\mu$  in diameter. Rhizoidal system richly branched. Zoospores oval, 2.5-3 $\mu$ , with a .5 to 1 $\mu$  in diameter refractive globule, and a 12 $\mu$  long flagellum. Resting spores extramatrical, hyaline, smooth, oval to spherical, 7-10 $\mu$ , with one large and several small refractive globules; germination unknown.

Parasitic in adults and eggs or cysts of nematodes in soil samples from San Carlos, Matto Grosso, Brazil.

This species was found several times on eggs or cyst and thrice on adult nematodes. It appears to be a virulent parasite of eggs but whether or not it is capable of killing active adults is uncertain. All of the infected nematodes were dead at the time they were found, and it is not certain whether they had been killed by *P. nematodeae* or by some other agent. So far, this chytrid has not been found on rotifer eggs, and all attempts to infect algae with it have failed.

The development of this species is so similar to that of other known members of the genus that it is unnecessary to describe it in detail. The zoospores (fig. 35) emerge from one (fig. 37) or two deliquesced papilla and form a globular mass at the exit orifice. However, this mass becomes dispersed before all of the spores have emerged, so that those remaining in the sporangium escape singly and dart immediately away. They remain motile for twenty to fifty minutes and often become intermittently amoeboid (figs. 35 a, b). After coming to rest on the host (fig. 36) they form a short penetration tube which branches and develops into the intramatrical rhizoidal system and apophysis, while the zoospore body enlarges and develops into the extramatrical sporangium as in other species of *Phyllochytium*. So far only a few resting spores have been found. These develop extramatrically (fig. 38) like the sporangia up to a certain stage and then accumulate numerous refractive globules. As the wall begins to thicken the globules coalesce to form one or more larger ones (fig. 38 b).

#### RHIZOPHYDIUM GIBBOSUM AND R. ZOOPHTHORUM

Among the numerous species of *Rhizophydium* found in Brazil were two which occurred on eggs of rotifers in watered soil samples from San Carlos, Matto Grosso. The first of these is characterized primarily by irregular gibbose sporangia and minute zoospores which contain one or more small globules. By these characters it is identical to the species found by Zopf (1888) on various desmids and rotifer eggs in Germany, which he named *Rhizophyton gibbosum*. This species was subsequently transferred to *Rhizophydium* by Schroeter (1889) and has since been known as *R. gib-*



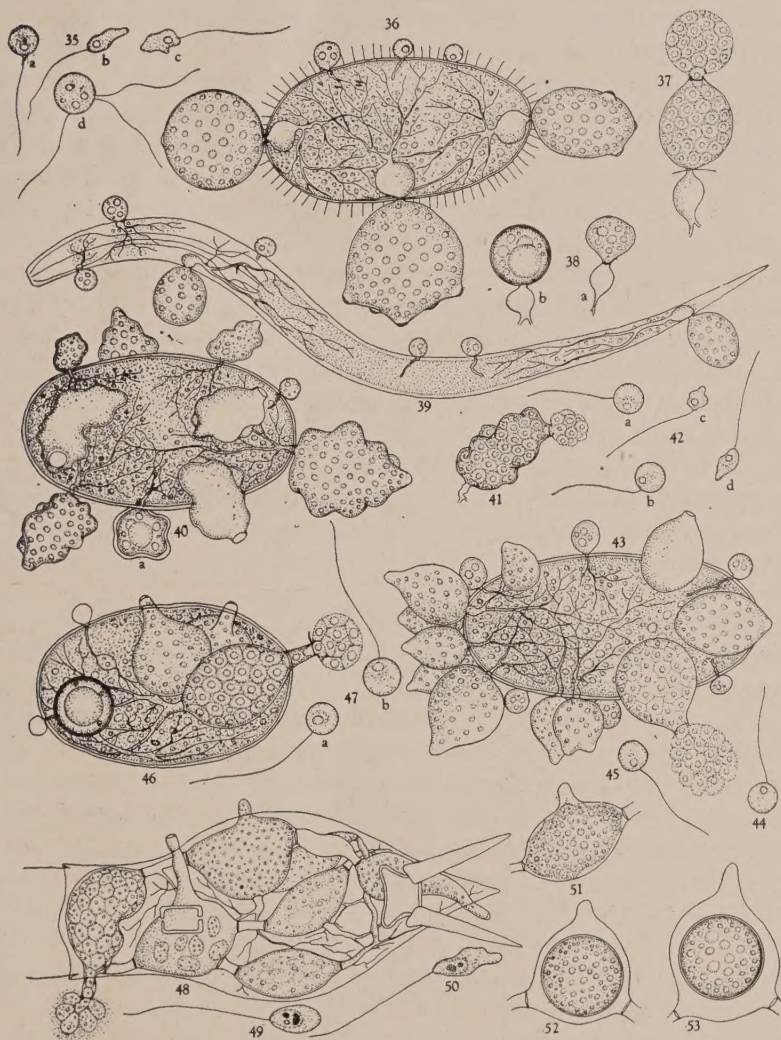


PLATE 2. Figs. 35-38.—*Phlyctochytrium nematodeae*. 35 a, b, c, d. Spherical, amoeboid, and abnormal multiflagellate zoospores, respectively. 36. Greatly enlarged nematode egg with six parasites. 37. Discharge of zoospores from sporangium. 38 a, b. Stages in resting spore development. 39. Mature nematode with seven parasites. Figs. 40-42.—*Rhizophydium gibbosum*. 40. Rotifer egg with nine sporangia and one resting spore. 41. Discharge of zoospores. 42 a, b, c, d. Spherical and amoeboid zoospores. Figs. 43-45.—*Rhizophydium zoophthorum*. 43. Rotifer egg with seventeen parasites. 44, 45. Zoospores. Fig. 46, 47.—*Endochytrium operculatum*. 46. Rotifer egg with four thalli and one resting spore. 47. Zoospores. Figs. 48-53.—*Catenaria anguillulae*. 48. Adult rotifer with internal rhizomycelium. 49, 50. Zoospores. 51-53. Stages of the development of resting spores.



*bosum*. The method of development, size and shape of the sporangia (fig. 45), branching of the rhizoids, method of zoospore discharge (fig. 41), as well as the appearance, size, shape and behavior of the zoospores (fig. 42) in the Brazilian material are similar to those described by Zopf, and no fundamental differences have been found. However, a few resting spores developed as the cultures became old. These occurred extramatrically (fig. 40 a) and are irregular in shape, 6 to  $12\mu$  in diameter, hyaline and smooth with one to several large refractive globules in the cytoplasm. So far germination has not been observed.

The second species, illustrated in figs. 43 to 45, is characterized by pyriform or oval sporangia with a prominent tapering apex and by a fairly stout branched rhizoidal system. The sporangia are usually closely crowded on the surface of the egg and sometimes become angular in shape because of mutual contact and pressure. In these characteristics as well as methods of zoospore discharge, size, shape, appearance and behavior of the zoospores, it is identical to *Rhizophydium zoophthorum* which Dangeard (1887, 1889) first found on rotifer eggs in France more than fifty years ago. Resting spores are unknown in this species, and none were found in the Brazilian material.

#### ENDOCYTRIUM OPERCULATUM

This intramatrical operculate chytrid occurs normally as a saprophyte in decaying vegetation in water (Karling, 1937), but it may occasionally attack the cysts and eggs of microscopic animals. It was found on numerous occasions in rotifer eggs from soil samples collected at San Carlos, Matto Grosso and near Manaus, Amazonas in Brazil. Figure 46 shows an infected egg from San Carlos with three mature sporangia, one resting spore and a very young developing thallus. The sporangia, resting spores and zoospores of the Brazilian specimens are similar in every respect to those described by the author (1937) from the U.S.A., and there is no doubt that they relate to *E. operculatum*. In this connection it may be noted that Sparrow (1933) described *E. oophilum* as a parasite of rotifer eggs in New York. Since he found no rhizoids, he assigned his fungus provisionally to *Endochytrium*. As the present writer pointed out previously (1937) if *E. oophilum* actually belongs in *Endochytrium* it is doubtless identical to *E. operculatum*, because the latter species will readily infect microscopic animals as well as plant hosts.

#### CATENARIA ANGUILLULAE

This polycentric species was found on several occasions in the body of adult rotifers in watered soil cultures collected on the banks of the Rio Madeira at Porto Velho, Amazonas. All of the infected rotifers were dead at the time of discovery, so that it is not certain that they had been killed



by this fungus or some other agent. Since *Catenaria anguillulae* may grow readily as a saprophyte in dead plant tissues (Karling, 1934) and on synthetic agar media (Butler and Humphries, 1932) it is possible that the thallus shown in figure 48 was a secondary invader. The sporangia, zoospores and resting spores of the South American specimens were similar to those reported from Europe and North America, and no outstanding differences were found. Resting spores occurred sporadically, and these were formed in the same manner described by Buckley and Clapham (1929). The content of thallus segments or incipient sporangia contracts (fig. 51), encyst (fig. 52) becomes enveloped by a thick hyaline wall (fig. 53) and lies free in the surrounding vesicle. Buckley and Clapham found that the spores germinate within the vesicles and give rise directly to exit tubes and posteriorly uniflagellate zoospores, but no germination stages have yet been seen in the Brazilian material.

#### SUMMARY

Two new species of *Olpidium*, *O. granulatum* and *O. rotiferum*, were found parasitizing rotifer eggs and adults collected at San Carlos, Matto Grosso, and Manaus, Amazonas in Brazil. *Olpidium granulatum* is characterized by small spherical zoospores which contain numerous minute granules and by hyaline oval or spherical resting spores, whereas *Olpidium gregarium* is distinguishable by large oblong zoospores. In addition to these chytrids a new species of *Phlyctochytrium*, *P. nematodeae*, was found parasitizing eggs and adult nematodes. It is the only known species of this genus which attacks animals and apparently does not infect algae. It is characterized by minute zoospores, spherical, oval or slightly urceolate sporangia, and oval or spherical, hyaline, smooth resting spores. *Rhizophyidium gibbosum*, *R. zoophthorum*, *Endochytrium operculatum* and *Catenaria Anguillulae* were also found on and in rotifer eggs and adults in Brazil.

#### LITERATURE CITED

- BUTLER, E. J. 1907. An account of the genus *Pythium* and some Chytridiaceae. Mem. Dept. Agric. Indian 1, 5: 1-160.
- BUTLER, J. B. and A. HUMPHRIES. 1932. On the cultivation in artificial media of *Caternaria Anguillulae*, a chytridiacean parasite of the ova of the liver fluke, *Fasciola hepatica*. Sci. proc. Roy. Dublin Soc. 20: 301-324.
- BUCKLEY, J. J. C. and P. A. CLAPHAM. 1929. The invasion of helminth eggs by chytridiacean fungi. Jour. Helminth. 7: 1-14.
- CONSTANTINEANU, J. C. 1901. Contributions a la flore mycologique de la Roumaine. Rev. Gén. Bot. 13: 368-389.
- DANGEARD, P. A. 1887. Notes mycologiques. Bull. Bot. Soc. France 34: XXI-XV.
- 1889. Memoire sur les Chytridinées. Le Bot. 1: 39-74.
- KARLING, J. S. 1934. A saprophytic species of *Catenaria* isolated from roots of *Panicum variegatum*. Mycologia 26: 528-543.
- 1937. The structure, development, identity and relationship of *Endochytrium*. Amer. Jour. Bot. 24: 352-364.



- 1942. Parasitism among chytrids. *Ibid.* **29**: 24-35.
- 1944. New lagenidiaceous parasites of rotifers from Brazil. *Lloydia* **7**(4) 328-342.
- NOWAKOWSKI, L. 1876. Beitrag zur Kenntniss der Chytridiaceen Cohn's Beitr. Biol. Pflanz. **2**: 73-100.
- SCHERFFEL, A. 1926. Einiges über neue oder ungenügend bekannte Chytridineen. Arch. Protistk. **54**: 167-260.
- SCHROETER, J. 1889. Chytridei. Cohn's Krypt.-Fl. Schlesiens **3**: 175-197.
- SPARROW, F. K. 1933. Observations on operculate chytridiaceous fungi collected in the vicinity of Ithaca, N. Y. Amer. Jour Bot. **20**: 63-77.
- 1936. A contribution to our knowledge of the aquatic Phycomycetes of Great Britain. Jour. Linn. Soc. London, Botany **50**: 417-478.
- 1943. Aquatic phycomycetes. Univ. of Mich. Studies, Sci. Ser. **15**: 95.
- WATERHOUSE, G. M. 1940. A chytrid allied to *Pleolpidium inflatum* Butler. Trans. Brit. Mycol. Soc. **24**: 7-19.
- ZOPF, W. 1888. Zur Kenntniss der Infections Krankheiten niederer Thiere und Pflanzen. Nova Acta Ksl.-Leop. Carol. Deut. Akad. Naturforsch. **52**: 313-376.



# Physiological Studies on Some Members of the Family Saprolegniaceae. V. Growth Substances\*

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## INTRODUCTION

The importance of growth substances in the metabolism and growth of plants and animals has now been well established. Many fungi, for instance, can grow on a medium containing some minerals as well as suitable carbon and nitrogen sources, out of which they can manufacture the growth substances required for their normal and perhaps optimal growth. Such species do not need an external supply of growth substances. There are other species which are unable to grow without an extraneous supply of growth substances, which they are incapable of synthesizing themselves. The third category consists of organisms which grow slowly in the absence of an external supply of growth substances, but more rapidly if these are added to the medium. Such organisms are capable of manufacturing their own growth substances, but do so at a sub-optimal rate. In such cases the deficiency of growth substances acts as a limiting factor and their addition results in a marked acceleration of growth. The organisms belonging to the first category described above are called "autotrophic" species while the other two types are referred to as "heterotrophic" species. Some of the latter forms have a "complete deficiency" for one or more vitamins, while others suffer from "partial deficiencies."

During the last few years a great amount of precise work has been done in this connection. Unfortunately, too many terms have been introduced to designate growth substances such as accessory growth factors, auximones, auxithals, ergones, growth activators, growth factors, nutrilites, plant hormones and vitamins. The literature about growth substances is now so extensive that it is neither possible nor advisable to include a review of it in this paper. For comprehensive surveys of the literature concerning the role of growth substances, the reader is referred to Went (1935), Bonner (1937), Robbins and Kavanagh (1941, 1942), Carroll (1943), and Schopfer (1943).

Yet very little work has been done on the effects of various growth promoting substances on the members of the family Saprolegniaceae. Leonian and Lilly (1937) found that *Plectospora gemmifera* and *Saprolegnia diclina* did not grow on a medium consisting of  $\text{KH}_2\text{PO}_4$ ,  $\text{MgCl}_2$ ,  $\text{MgSO}_4$ ,  $\text{NH}_4\text{NO}_3$  and dextrose. Addition of heteroauxin caused no response but

\* Part of thesis approved for the degree of Doctor of Philosophy in the University of Allahabad.

good growth was obtained with the addition of yeast extract. Wolf (1937) reported that a definite inhibition of growth occurred in *Achlya bisexualis* and *Saprolegnia ferax* following the addition of alphanaphthalene acetic acid in concentrations 1:1,000,000 or higher. Leonian and Lilly (1938) also tested the effect of thiamin on *Achlya conspicua*, *Aphanomyces camptostylus*, *Isoachlya monilifera*, *Saprolegnia parasitica* etc. without obtaining positive results. Murdia (1939) studied the effect of  $\beta$ -indolyl 3-acetic acid and phenyl acetic acid on the growth of some saprolegniaceous fungi. *Thraustotheca clavata* was listed as a biotin deficient organism by Leonian and Lilly (1940). Saksena and Bhargava (1941) studied the effect of vitamin B<sub>1</sub> on the growth of *Saprolegnia delica*.

*Achlya* sp., *Brevilegnia gracilis* v. Eek, *Isoachlya anisospora* (de Bary) Coker var. *indica* Sak. et Bhar. and *Saprolegnia monoica* Pringsh. have been used in the present investigation which deals with (1) the synthesis of growth substances, (2) the effect of light on the yield of thiamin, and (3) the effect of vitamins B<sub>1</sub>, B<sub>2</sub>, C thyroxin and  $\beta$ -indolyl 3-acetic acid on the growth of these organisms.

#### METHODS

Since growth substances are effective only in most minute amounts and are widely distributed in the products of natural origin, much emphasis has been laid on the details of techniques used in experimental work dealing with these substances. These methods have been thoroughly discussed by Peskett (1933), Koser and Saunders (1938) and Robbins and Kavanagh (1938c, 1942), and the important precautions pointed out by them have been closely followed in these experiments.

The following nutrient media were prepared:

Medium A containing 0.5 gm. each of K<sub>2</sub>HPO<sub>4</sub>, MgCl<sub>2</sub>·6H<sub>2</sub>O, 2.0 gms. NH<sub>4</sub>NO<sub>3</sub>, 0.05 gm. cystin, 5.0 gms. pure dextrose and 1000 cc. double distilled water.

Medium B containing all the ingredients of medium A but in place of 0.05 gm. cystin, there was 0.5 gm. K<sub>2</sub>SO<sub>4</sub>.

Medium C containing 0.5 gm. each of K<sub>2</sub>HPO<sub>4</sub>, MgCl<sub>2</sub>·6H<sub>2</sub>O and K<sub>2</sub>SO<sub>4</sub>, 1.0 gm. NH<sub>4</sub>NO<sub>3</sub>, 1.0 gm. purified asparagin, 5 gms. pure dextrose and 1000 cc. double distilled water.

Medium D containing all the ingredients of medium C but double distilled water was only 250 cc.

For the solidification of media Difco bacto agar was used.

Throughout the entire investigation only Pyrex glassware was used. The apparatus was thoroughly cleaned and washed several times with distilled water. Only guaranteed reagents (*proanalysis* of Merck or Analar of British Drug House) were used. Thiamin was vitamin B<sub>1</sub>, vitamin B<sub>2</sub> was lacto-



flavin and vitamin C was ascorbic acid of Hoffmann-Roche (Switz.). Thyroxin and  $\beta$ -indolyl 3-acetic acid (heteroauxin) were obtained from British Drug House. Solutions of these substances were prepared so as to give 25 international units per 1 cc. of the solution. The unit of vitamin chosen is the same as that employed by Robbins and Kavanagh (1938c) and is equal to  $10^{-9}$  mole of the compound. These substances were added to the solutions before autoclaving.

Asparagine was purified by repeated precipitations with alcohol and the purification of agar was carried on by treatment with pyridine and alcohol (Robbins and Ma 1941, p. 448).

Various media were sterilized in an autoclave for 15 minutes at 15 pounds pressure. All cultures were grown in triplicate. The temperature, unless otherwise stated, was 25°C. For sterile filtration Seitz sterile filter was employed.

*Achlya* sp., *Brevilegnia gracilis*, *Isoachlya anisospora* var. *indica*, *Saprolegnia monoica* and the test fungi used, i.e., *Phytophthora erythroseptica* Pethy. and + strain of *Phycomyces blakesleeanus* Burgeff, were maintained on oatmeal agar.

The known methods for quantitative determination of thiamin can be found in books by Williams and Spies (1938) and by Harris (1938). A very sensitive and simple test involves the use of the fungus *Phycomyces blakesleeanus*, growth of which is controlled largely by the amounts of thiamin (Schopfer 1934) or its components supplied in culture media (Robbins and Kavanagh 1937, 1938a, b). This method measures the cumulative activity of thiamin, its two components and cocarboxylase. Since some unidentified substances may stimulate somewhat the growth of the fungus in the presence of thiamin (Robbins and Hamner 1940), this method gives only an approximation of thiamin and related compounds. *Phytophthora erythroseptica* was also employed in the assay method.

#### EXPERIMENTAL

Series 1.—Media A, B and C were inoculated with *Phytophthora erythroseptica* and *Phycomyces blakesleeanus*, but there was no growth in any case. These two fungi responded if thiamin was added to these media.

Series 2.—*Achlya* sp., *Isoachlya anisospora* var. *indica* and *Saprolegnia monoica* were grown on medium A and *Brevilegnia gracilis* on medium B. The fungi showed good growth and were indefinitely transferable on the media.

Series 3.—Flasks containing 60 cc. of medium A were inoculated with *Achlya* sp., *Isoachlya anisospora* var. *indica* and *Saprolegnia monoica*, whereas flasks containing 60 cc. of medium B were inoculated with *Brevilegnia gracilis*. One set of cultures was kept in total darkness and the other was subjected to constant light at laboratory temperature (20°–22°C.) for

14 days. It was noticed that the colonies of fungi ramified in the medium.

(a) In each case the mycelium was removed from the three flasks of each set, and washed well in distilled water which was changed several times. It was ground and added to 200 cc. of medium C which was then heated in an autoclave for 5 minutes at 5 pounds pressure, filtered sterile and poured in five sterilized flasks. These were then incubated for 3 days at 30°C. The uncontaminated ones were inoculated with the test fungi.

(b) In each case 25 cc. of medium D was added to 125 cc. of the staled medium from which the mycelium was removed as described under series 3 a. The pH of the medium was adjusted to 7 by N/10 KOH solution and the medium was then filtered sterile, and poured in five sterilized flasks. The flasks were then incubated for 3 days at 30°C. The uncon-

TABLE 1. Dry weight (in mgs.) of the test fungi grown for 15 days on media used in Series III a and b. Temperature=25°C.

	<i>Phytophthora erythroseptica</i>				<i>Phycomyces blakesleeanus</i>			
	Medium D +staled medium		Medium C +mycelial extract		Medium D +staled medium		Medium C +mycelial extract	
	Light	Dark- ness	Light	Dark- ness	Light	Dark- ness	Light	Dark- ness
<i>Achlya</i> sp.	6.0	14.0	5.0	8.3	14.3	29.5	7.0	12.5
<i>B. gracilis</i>	12.5	34.0	14.3	43.3	12.0	28.0	11.0	35.0
<i>I. anisospora</i> var. <i>indica</i>	7.5	19.0	5.5	13.3	13.0	35.0	9.0	23.0
<i>S. monoica</i>	10.3	23.2	6.0	16.3	12.0	30.0	7.5	26.5

taminated ones were inoculated with the test fungi. The period of incubation was 15 days at 25°C.

It was found that the test fungi gave appreciable growth in all experiments in the case of each fungus (Figs. 1-8). Dry weight of the colonies obtained is given in table 1.

The results tabulated in table 1 indicate that the test fungi gave more growth when they were grown on medium D containing the staled medium than on those containing the mycelial extracts of *Achlya* sp., *Isoachlya anisospora* var. *indica*, and *Saprolegnia monoica*, but reverse results were obtained in the case of *Brevilegnia gracilis*. Another important conclusion derived is that the growth of the test fungi was greater on media obtained from the set of cultures kept in total darkness than from those kept in light.

Series 4.—Media A and B were supplemented with various growth substances in different concentrations (5, 50 and 100 units per 25 cc. of the medium) singly and experiments were performed in Petri dishes and flasks.



TABLE 2. *Diametric spread (in cms.) of the fungal colonies on solidified medium A and B with and without growth substances, Temperature 25° C.*

Fungi	At the end of (hrs.)	Without growth sub- stances	Supplemented with vitamin B <sub>1</sub> , each dish containing (units)			Supplemented with vitamin B <sub>2</sub> , each dish containing (units)			Supplemented with vitamin C, each dish containing (units)			Supplemented with thyroxin, each dish containing (units)			Supplemented with indolyl acetic acid, each dish containing (units)		
			5	50	100	5	50	100	5	50	100	5	50	100	5	50	100
<i>Achlya</i> sp.																	
	24	1.5	1.6	1.5	1.5	1.5	1.6	1.5	1.5	1.4	1.5	1.5	1.4	1.4	1.5	1.5	1.3
	48	2.7	2.7	2.8	2.7	2.8	2.8	2.6	2.6	2.7	2.7	2.7	2.5	2.5	2.6	2.6	2.3
<i>B. gracilis</i>	72	3.7	3.7	3.7	3.6	3.8	3.7	3.5	3.5	3.5	3.4	3.7	3.5	3.1	3.5	3.2	3.2
	24	5.9	6.1	6.1	6.2	6.1	6.1	6.2	6.0	6.2	6.0	6.1	6.2	5.9	6.0	5.8	5.7
	48	11.5	11.5	11.5	11.4	11.5	11.5	11.6	11.4	11.5	11.0	11.5	11.6	11.5	11.5	11.2	11.0
<i>I. anisopora</i> var. <i>indica</i>	24	3.4	3.4	3.5	3.5	3.3	2.9	2.8	3.1	2.9	2.7	3.3	3.4	3.2	3.2	2.7	2.5
	48	5.5	5.5	5.6	5.4	5.3	5.1	4.9	5.1	4.8	4.7	5.4	5.5	5.2	5.0	4.8	4.5
	72	7.6	7.6	7.7	7.5	7.4	7.2	7.0	7.2	6.9	6.8	7.4	7.5	7.2	7.5	6.9	6.5
<i>S. monoica</i>	24	1.5	1.5	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.3	1.5	1.4	1.3	1.5	1.3	1.2
	48	2.6	2.6	2.5	2.4	2.5	2.6	2.6	2.6	2.4	2.3	2.6	2.5	2.1	2.4	2.2	2.0
	72	3.6	3.6	3.3	3.0	3.5	3.5	3.4	3.6	3.4	3.2	3.6	3.5	3.2	3.2	3.1	3.0

Media A and B served as control. The inoculum was cut off from the margin of the young colony maintained on solid medium A or B in each case. The results are summarized in tables 2 and 3.

The results obtained above indicate that the growth of the fungi on media supplemented with different doses of thiamin was nearly the same as that on the control. Vitamins B<sub>2</sub>, C and  $\beta$ -indolyl 3-acetic acid have similar effects when supplied in lower doses (i.e., 5 and 50 units per 25 cc. of

TABLE 3. Dry weight of mycelium (in mgs.) of the fungi grown for 14 days in flasks on medium A and B with and without growth substances. Temperature = 25°C.

Growth substances		<i>Achlya</i> sp.	<i>B. gracilis</i>	<i>I. anisospora</i> var. <i>indica</i>	<i>S. monoica</i>
Name	Amount in each flask (in units)				
B <sub>1</sub>	5	48.3	33.6	35.0	43.6
	50	45.0	31.6	32.6	43.6
	100	48.0	34.5	29.3	38.8
B <sub>2</sub>	5	47.6	32.0	32.3	38.5
	50	41.0	31.6	30.0	36.6
	100	40.0	30.3	26.6	34.3
C	5	42.0	34.0	33.3	40.0
	50	42.3	33.5	31.6	36.0
	100	37.3	29.6	30.6	32.0
Thyroxin	5	43.3	32.0	34.0	36.6
	50	38.3	30.3	31.0	35.3
	100	38.0	27.6	31.0	30.0
Indolyl acetic acid	5	42.3	34.0	32.6	36.0
	50	40.0	31.6	31.0	35.0
	100	35.6	26.0	28.6	30.0
Control	0	44.0	35.0	36.0	40.0

the medium). Higher concentrations (100 units per 25 cc. of the medium) of these three substances retarded the growth of the organisms. Thyroxin was harmful when supplied in 50 and 100 units per 25 cc. of the medium.

Series 5.—The fungi were grown on Difco bacto agar, purified Difco bacto agar and purified bacto agar supplemented with agar extract. It was found that *Brevilegnia gracilis* was able to grow on all three media but *Achlya* sp., *Isoachlya anisospora* var. *indica* and *Saprolegnia monoica* grew only on Difco bacto agar and purified bacto agar supplemented with agar extract. The latter did not grow on purified bacto agar alone.



## DISCUSSION

Since *Achlya* sp., *Isoachlya anisospora* var. *indica* and *Saprolegnia monoica* were able to grow and were transferable on medium A and *Brevilegnia gracilis* was able to grow on medium B (Series 2), both of which were free from the significant amounts of thiamin and its components (Series 4), it is clear that these fungi do not require thiamin from an external source for their growth.

It is now well established that the growth of *Phytophthora erythroseptica* and *Phycomyces blakesleeana* is controlled by thiamin or its components respectively, and it has been demonstrated above that they did not grow on media A, B, C and D. Since these two fungi grew well on the media used in series 3a and b, it can be safely assumed that the required thiamin and probably its intermediates were present in the extracts of the mycelium (Series 3a), and that part of the synthesized vitamin was also given off by the mycelium into the solution (Series 3b). These species behave like *Cunninghamella blakesleeana* Lender (Leonian and Lilly 1938, p. 540), *Saprolegnia delica* Coker (Saksena and Bhargava 1941) and some species of *Pythium* (Saksena 1941) which synthesize their own thiamin from the ingredients of the nutrient medium.

From the results summarized in table 1, it is clear that the yield of growth substance in cultures kept in total darkness is greater than that in cultures subjected to constant light. Robbins and Kavanagh (1941, p. 496) have reported that many plants (bacteria and fungi) which lack chlorophyll synthesize thiamin in the dark. On the other hand Thimann and Dolk (1933) obtained data indicating higher yield of growth substance in illuminated cultures than in those kept in the dark. Occasionally they too got higher value for cultures kept in the dark. Later they (Thimann and Dolk 1933, p. 60) remark, "The data we have obtained are, however, far from conclusive . . . It is hoped to carry out conclusive experiments at a later date."

Results of experiments carried on as series 4 and tabulated in tables 3 and 4 indicate that the addition of thiamin has no marked effect on the growth of these fungi. The differences which appear are within the limits of experimental error, and are therefore, not significant. In this respect these fungi resemble *Agaricus campestris* Linn., *Absidia glauca* Hagem, *Basidiobolus ranarum* Eidem, *Cunninghamella* sp. no. 102, *Mucor circinelloides* v. Tiegham (Robbins and Kavanagh 1938), *Saprolegnia delica* Coker (Saksena and Bhargava 1941) and some species of *Pythium* (Saksena 1941). These results also indicate that these fungi synthesized the required quantity of thiamin and, therefore, an external dose of thiamin did not increase their growth.

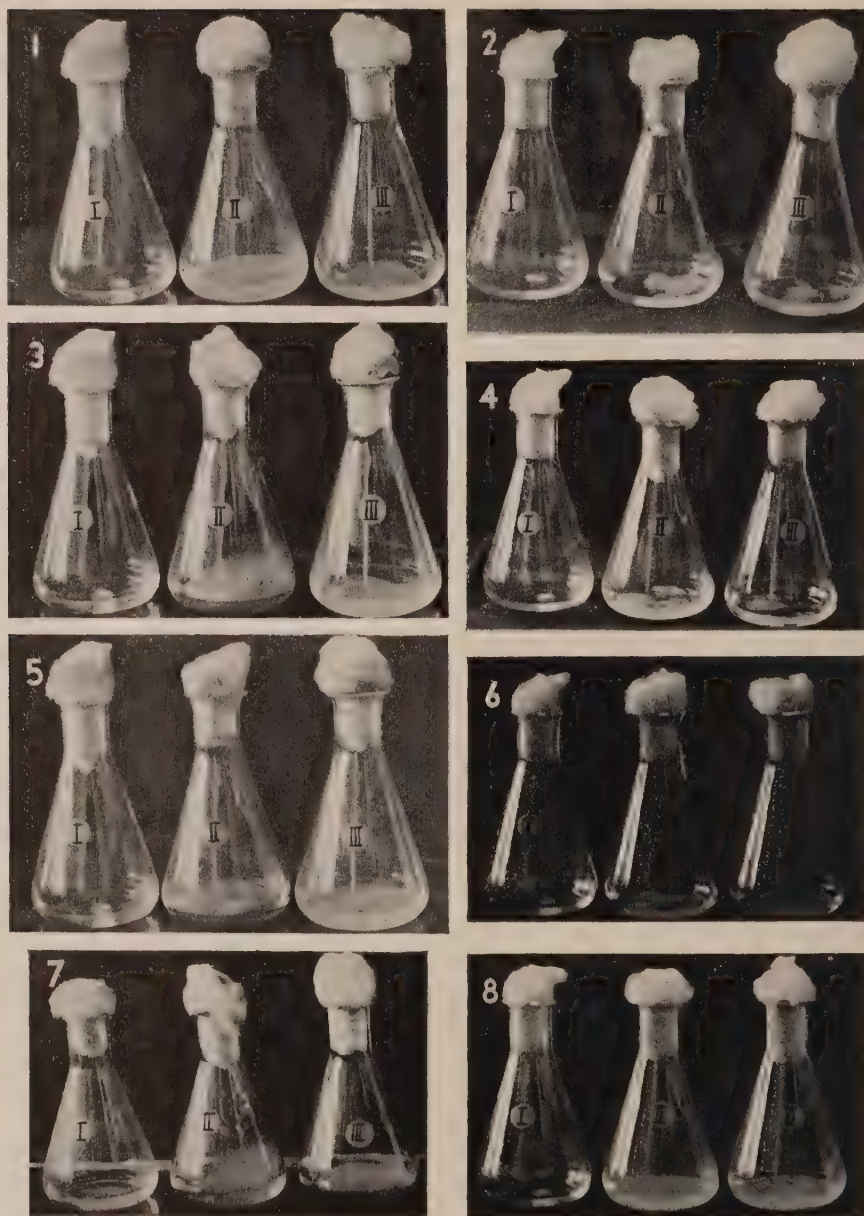


FIG. 1. Growth of *Phycomyces blakesleeanus* on medium C (I), staled medium (II) and mycelial extract (III) of *Achlya* sp. FIG. 2. Growth of *Phytophthora erythroseptica* on media used in Fig. 1. FIG. 3. Growth of *Phycomyces blakesleeanus* on medium C (I), staled medium (II) and mycelial extract (III) of *Isoachlya anisospora* var. *indica*. FIG. 4. Growth of *Phytophthora erythroseptica* on media used in Fig. 3. FIG. 5. Growth of *Phycomyces blakesleeanus* on medium C (I), staled medium (II) and mycelial extract (III) of *Saprolegnia monoica*. FIG. 6. Growth of *Phytophthora erythroseptica* on media used in Fig. 5. FIG. 7. Growth of *Phycomyces blakesleeanus* on medium C (I), mycelial extract (II) and staled medium (III) of *Brevilegnia gracilis*. FIG. 8. Growth of *Phytophthora erythroseptica* on media used in Fig. 7.



Addition of vitamin B<sub>2</sub> (lactoflavin) does not improve the growth of the fungi. In higher concentration (100 units per 25 cc. of the medium), however, it has a tendency towards retardation of growth.

Ascorbic acid (vitamin C), though occurring abundantly in plants, appears to be without any growth promoting effect. In the present case, it too has a tendency towards retardation of growth. Kögl and Haagen Smit (1936) also report that ascorbic acid appears to be without a growth promoting effect. Das Gupta and Guha (1941) report that the addition of ascorbic acid to the nutrient medium in a concentration of 1/50,000 produces stimulation of growth of *Aspergillus niger*, *A. oryzae* and *Saccharomyces cerevisiae* etc. in the beginning, which later becomes roughly equal to that of the controls. It has an inhibitory effect on their growth in a concentration of 1/10,000.

Thyroxin and  $\beta$ -indolyl 3-acetic acid are without effect in low concentration but in higher doses they retard the growth. Leonian and Lilly (1937) report that low concentrations of heteroauxin do not induce any stimulation and higher concentrations are toxic to the growth of *Plectospora gemmifera* and *Saprolegnia diclina*. For heteroauxin they (1937, p. 139) remark, "heteroauxin is a growth-inhibiting rather than a growth promoting substance. It may be possible that acting like a powerful stimulant or irritant, it induces the formation, the transportation to, and the concentration in the invaded region of large quantities of the growth substances of the plant. This constant drain may eventually lead to weakening and ultimate death unless the foreign substance is removed or neutralized." Murdia (1939) reports that  $\beta$ -indolyl 3-acetic acid is of no value as a growth stimulant. It rather inhibits the growth in higher concentrations in the case of *Achlya dubia*, *Aphanomyces camptostylus*, *A. cladogamus*, *Pythiopsis intermedia* and *Thraustotheca clavata*.

Robbins and Ma (1941, p. 461) have reported that extraction of agar with aqueous pyridine removed all or almost all of biotin. The results of experiments described under series 5 indicate that *Achlya* sp., *Isoachlya anisospora* var. *indica* and *Saprolegnia monoica* may be biotin deficient organisms, being incapable of growing on purified Difco agar but showing growth with the addition of agar extract to the purified Difco agar. Leonian and Lilly (1940) listed *Thraustotheca clavata* a related genus, among biotin deficient organisms.

A reasonable objection can be raised here that the absence of growth of the organisms on purified Difco agar may be due to the removal of necessary minerals during the process of purification. Since *Brevilegnia gracilis* is capable of growing on purified Difco agar it is assumed that the necessary amount of minerals is retained by the agar even after purification. In spite of best efforts the author failed to procure mineral salts and sugars free from biotin to add to the purified agar. Therefore it cannot be said with certainty that they are biotin deficient organisms.

## SUMMARY

*Achlya* sp., *Brevilegnia gracilis*, *Isoachlya anisospora* var. *indica* and *Saprolegnia monoica* are capable of unlimited growth on a nutrient medium which does not contain any appreciable amount of thiamin or its components. They synthesize their own thiamin from the ingredients of the nutrient solution and some of the thiamin thus manufactured is also given off by the mycelium into the solution.

The amount of thiamin manufactured is greater in cultures kept in total darkness than in those exposed to constant light.

The addition of vitamins B<sub>1</sub>, B<sub>2</sub>, C, thyroxin and  $\beta$ -indolyl 3-acetic acid in low concentrations has no marked effect on the growth of these organisms. Higher concentrations of vitamins B<sub>2</sub>, C, thyroxin and  $\beta$ -indolyl acetic acid retard their growth.

The experimental results indicate that *Achlya* sp., *Isoachlya anisospora* var. *indica* and *Saprolegnia monoica* may be biotin deficient organisms whereas *Brevilegnia gracilis* does not require an external supply of biotin.

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## LITERATURE CITED

- BONNER, J. 1937. The role of vitamins in plant development. *Bot. Rev.* **3**: 616-640.  
 CARROLL, G. H. 1943. The rôle of ascorbic acid in plant nutrition. *Ibid.* **9**: 41-48.  
 DAS GUPTA, G. H. AND GUHA, B. C. 1941. The effect of vitamin C and certain other substances on the growth of microorganisms. *Ann. Bio. & Exp. Med.* **1**: 14-26.  
 HARRIS, L. J. 1938. Vitamins and vitamin deficiencies. Churchill, London.  
 KÖGL, F. AND HAAGEN-SMIT, A. 1936. Mitteilung über pflanzliche Wachstum-stoffe. *Zeit. Physiol. Chem.* **243**: 209-226.  
 KOSER, S. A. AND SAUNDERS, F. 1938. Accessory growth factors for bacteria and related microorganisms. *Bact. Rev.* **2**: 99-160.  
 LEONIAN, L. H. AND LILLY, V. G. 1937. Is heteroauxin a growth-promoting substance? *Amer. Jour. Bot.* **24**: 135-139.  
 ——— 1938. Studies on the nutrition of fungi. I. Thiamin, its constituents, and the source of nitrogen. *Phytopath.* **28**: 531-538.  
 ——— 1940. Auxithals synthesized by some filamentous fungi. *Plant Physiol.* **15**: 515-525.  
 MURDIA, M. S. 1939. Effect of  $\beta$ -indolyl 3-acetic acid and Phenyl Acetic acid on the growth of some members of the family Saprolegniaceae. *Current Sci.* **8**: 362-363.  
 PESKETT, G. L. 1933. Growth factors for lower organisms. *Bio. Rev.* **8**: 1-45.  
 ROBBINS, W. J. AND HAMNER, K. C. 1940. Effect of potato extract on growth of *Phycomyces*. *Bot. Gaz.* **101**: 912-927.  
 ——— AND KAVANAGH, F. 1937. Intermediates of vitamin B<sub>1</sub> and growth of *Phycomyces*. *Proc. Nat. Acad. Sci. U. S. A.* **23**: 499-502.  
 ——— 1938a. The specificity of pyrimidine for *Phycomyces blakesleeanus*. *Ibid.* **24**: 141-145.



- 1938b. The specificity of thiazole for *Phycomyces blakesleeana*. Ibid. **24**: 145-147.
- 1938c. Vitamin B<sub>1</sub> or its intermediates and growth of certain fungi. Amer. Jour. Bot. **25**: 229-236.
- 1941. Plant growth substances. Ann. Rev. Biochem. **10**: 491-508.
- 1942. Vitamin deficiencies of the filamentous fungi. Bot. Rev. **5**: 411-471.
- AND MA, ROBERTA. 1941. Biotin and the growth of *Fusarium avenaceum*. Bull. Torrey Bot. Club **68**: 446-462.
- SAKSENA, R. K. 1941. Thiamin and growth of some species of *Pythium*. Proc. Ind. Acad. Sci. **14**: 141-148.
- AND BHARGAVA, K. S. 1941. A physiological study of *Saprolegnia delica* Coker. Proc. Nat. Acad. Sci. India **11**: 27-40.
- SCHOPFER, W. H. 1934. Les vitamines cristallisées B<sub>1</sub> comme hormones de croissance chez un microorganismes (*Phycomyces*). Arch. Mikrobiol. **5**: 511-549.
- 1943. Plants and Vitamins. Waltham, Mass.
- THIMANN, K. V. AND DOLK, H. E. 1933. Conditions governing the production of plant growth hormone by *Rhizopus* culture. Biol. Zbl. **53**: 49-66.
- WENT, F. 1935. Auxin, the plant growth hormone. Bot. Rev. **1**: 162.
- WILLIAMS, R. R. AND SPIES, T. D. 1938. Vitamin B<sub>1</sub> (thiamin) and its use in medicine. Macmillan, New York.
- WOLF, F. T. 1937. A nutritional study of *Achlya bisexualis* and *Saprolegnia ferax*. Amer. Jour. Bot. **24**: 119-123.

## Nuclear Cycle and Life History of a New Species of *Doassansia* (Ustilaginales)

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The diagnostic characters of the genus *Doassansia* Cornu (1883) are the presence of spore balls which are permanently embedded within the host tissues with a cortex of sterile cells. Only three species are reported from India (Mundkur 1940), viz. *Doassansia Nymphaeae* Syd. known only from the type collection made by Chibber on *Nymphaea stellata*, *D. Alismatis* (Nees) Cornu on the leaves of *Alisma plantago* collected by Butler in Kashmir and *Doassansiopsis Martianoффiana* (Thüm) Diet. also collected by Butler in Kashmir. None of the three above mentioned species has so far been reported from southern India. While collecting smuts near Nandi Hills, the writer came across a leaf smut of *Hygrophila* species growing in marshy places which on examination proved to be an unrecorded species of *Doassansia*. The details of the nuclear cycle and the life-history of the smut have been worked out and are here presented together with the description.

Material for cytological study was fixed in formalin acetic alcohol, and the microtome sections were stained with Heidenhain's iron-alum hematoxylin as well as Newton's iodine gentian violet. For the germination of the spores, the host tissue containing the sori was teased out. The spores separated from the spore balls were germinated and stained by the method suggested by the author (1940).

The smut is foliicolous and only once has it been observed on some of the calyx lobes. The first indication of the presence of the fungus is the appearance of circular pale-yellowish spots on the lower surface of the leaves. These spots gradually enlarge in width becoming orange-yellow in color on account of the spread of the mycelium within the host tissue. The sori begin their development in the center, whence they gradually expand concentrically in a centrifugal manner. The spore balls which are embedded within the host tissue, can be observed macroscopically as minute pustulate specks. In later stages the entire infection patch dries up and crumbles away leaving a circular pore resembling shot holes.

Sections through a young infection spot reveal the mycelium which is hyaline and which traverses the intercellular spaces. The host cells in the neighborhood lose their cell contents and turn orange-yellow in color. The hyphae are septate, thin-walled and distinctly binucleate. The fundamentals of the spore balls are formed by the grouping of the hyphae which branch repeatedly intertwining with one another and forming a spherical mass. Many of the hyphal cells begin to round off and later on develop into spores



(Fig. 4). This process is accompanied by the gelatinization of the walls. In a young sorus, the spores are compactly arranged; they are somewhat polygonal as a result of lateral compression. There is no indication of the presence of any unaltered hyphae surrounding this spore mass as noticed by Setchell (1892) in *D. Alismatis* (Nees) Cornu. The sterile cortical layer is formed by the transformation of the outermost layer of spores. The cells of the outermost layer enlarge and later on elongate in a radial direction. The nucleus degenerates and the cytoplasm becomes pressed to the margin, being replaced by large vacuoles. In the meanwhile, the two nuclei in the young fertile spores fuse to form a single fusion nucleus. The mature spores (Fig. 2) are hyaline, pale cinnamon yellow, thin-walled, polygonal and measure 10 to 15 $\mu$ . The cells of the sterile cortex are of a slightly deeper shade and measure 16.5–25 $\times$ 9–15 $\mu$ . The mature spore balls (Fig. 1) are large, subspherical or ovate to polygonal, occupying sometimes the entire mesophyll tissue between the upper and lower epidermis. Coalescence of several spore balls developing in close proximity has been noticed in many cases. The fertile spores entirely fill the space in the center conforming to the subgenus *Eudoassansia* of Setchell (1892). Except for minor variations, the type of development of the spores agrees in all respects with that given by Fisch (1884), Setchell (1892), Dangeard (1894) and others for the species of *Doassansia*.

The spores germinate readily without a period of rest being necessary. When sufficient moisture becomes available, the spores swell slightly and the germ tube extrudes after bursting the spore coat (Fig. 3). The fusion nucleus migrates into the aseptate promycelium thus formed, and in almost all cases observed, undergoes three successive divisions resulting in the formation of 8 free nuclei. When the promycelium has reached its full length (which at this stage is broader at the base and gradually tapers into a point), small papillate projections which are in fact the rudiments of sporidia, are differentiated at the tip. These elongate gradually until the mature sporidia, from 5 to 7 in number, are formed in a whorl at the tip. The sporidia are inserted equidistant from each other and spread out in a radiating manner. Each sporidium receives a single nucleus, and in those cases where only 5, 6 or 7 sporidia are formed, the supernumerary nuclei 3, 2 or 1 respectively as the case may be, are left in the promycelium (Fig. 7). Like conditions have been described by Rawitscher (1922) for *D. Sagittariae* (West) Fisch, Biraghi (1934) for *Urocystis Tritici* Koern., and probably occurs also in *D. Alismatis* (Lutman 1910). This clearly indicates that of the 8 sporidia which develop normally, only 5, 6 or 7 sporidia are actually produced. During the course of sporidial development, usually the cytoplasm is not used up entirely and a small quantity is thus left behind the promycelium. Following the depletion of the cytoplasmic contents, vacuoles appear in the promycelium and as the contents are with-

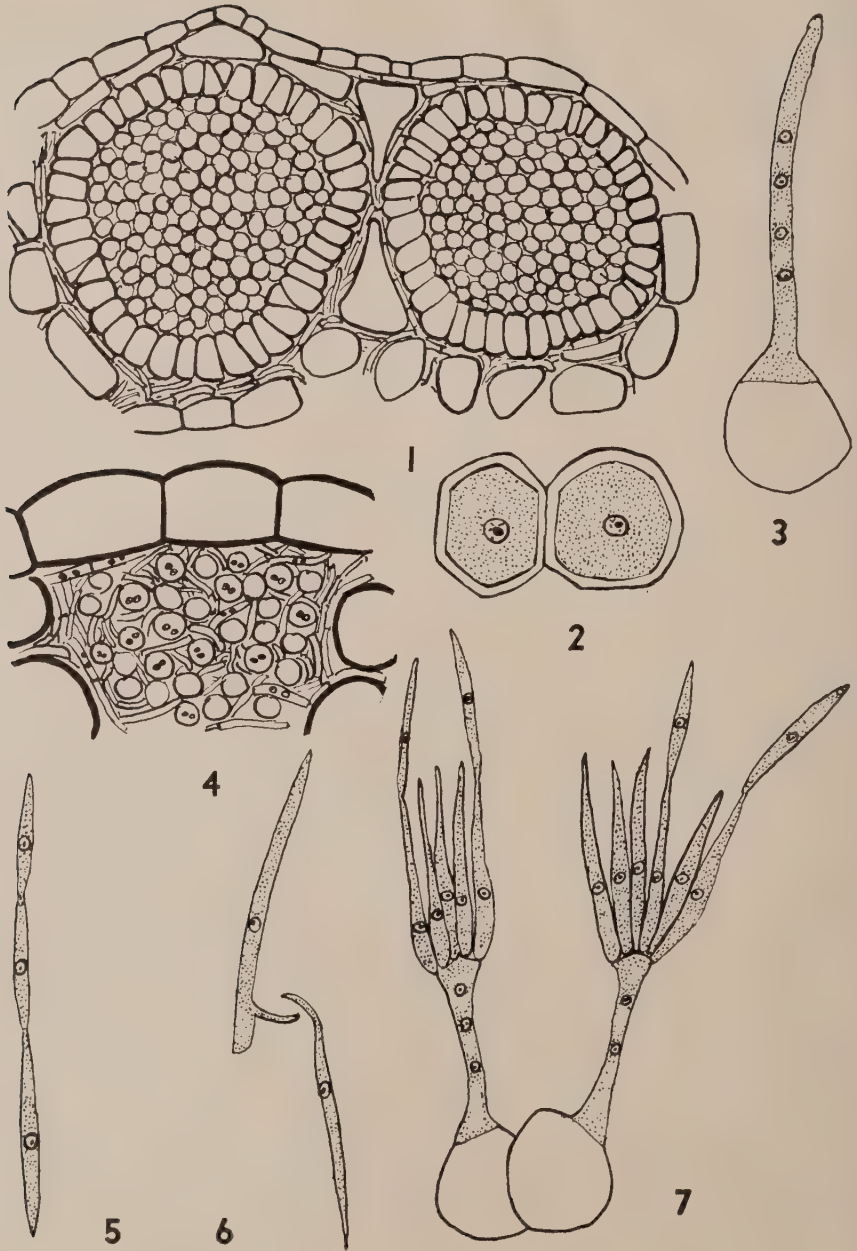


FIG. 1. Showing the spore balls within the host tissue,  $\times 200$ . FIG. 2. Mature spores,  $\times 800$ . FIG. 3. Germinating chlamydospore,  $\times 900$ . FIG. 4. Section through a young sorus,  $\times 1800$ . FIG. 5. Development of secondary and tertiary sporidia,  $\times 900$ . FIG. 6. Early stage in the formation of conjugation tubes,  $\times 1000$ . FIG. 7. Germination of chlamydospores,  $\times 900$ .



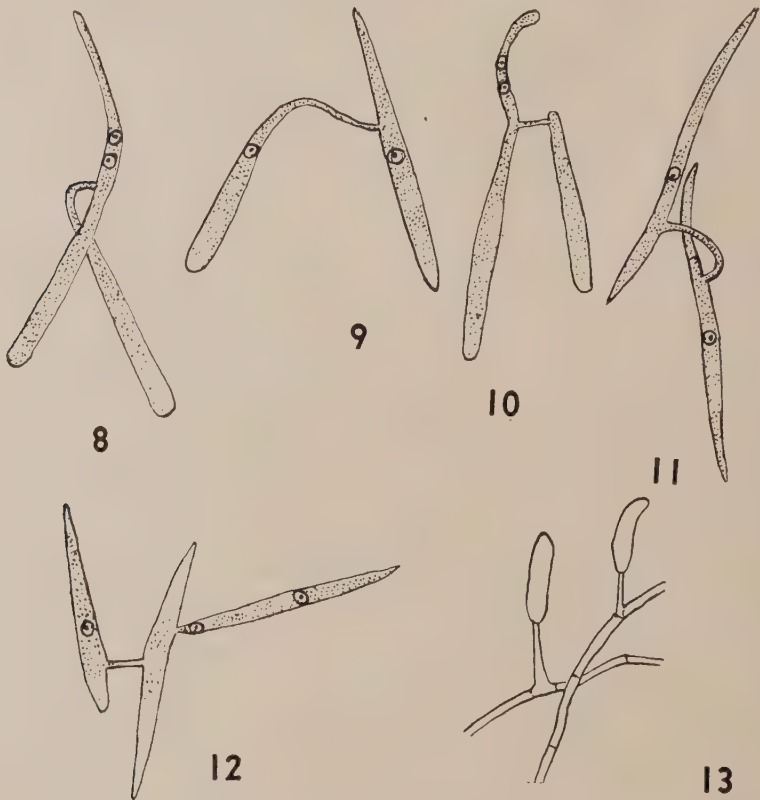
drawn towards the apex, one or rarely two septa are formed in the promycelium. This feature has been noticed by Setchell (1892) in many of the species of *Doassansia* studied by him.

Mature sporidia are fusiform, thin-walled, broader at the base than at the apex, slightly asymmetric, uni-nucleate and measure  $14-16 \times 1-1.2\mu$ . The sporidia do not show any signs of conjugation, but get readily separated from the promycelium. In many cases the formation of secondary sporidia (Fig. 7) even while still attached to the promycelium, and the formation of tertiary sporidia (Fig. 5) have been observed. The secondary and tertiary sporidia so formed are always developed in catenations acrogenously and never in whorls as in *D. obscura* Setchell. The secondary sporidia resemble the primary ones in all respects.

The sporidia begin to conjugate after separation from the promycelium. On the slides over which the spores were germinated, one could observe large numbers of conjugating sporidia floating in water. Though experimental evidence is still lacking, sporidia from the same promycelium apparently do not conjugate. On the other hand, sporidia derived from separate chlamydospores appear to conjugate after they get loosened from the promycelium and have come in contact with one another. In some cases in which single chlamydospores had germinated far apart, with their sporidial mass separated and lying close by, no sporidial fusions were observed, probably because they all belonged to the same chlamydospore. On the other hand, Setchell (1892) has shown that the sporidia of *D. Alismatis* develop conjugation tubes while still attached to the promycelium; however, conjugation has not been observed in *D. Sagittariae* which, according to Rawitscher (1922) and others, resembles *Ustilago Zeae* in the type of diploidization.

Prior to conjugation, each of two sporidia closely situated to one another develops a small recurved process (Fig. 6). These processes meet and fuse thereby establishing a direct connection. They can develop from any part of the sporidia, either at the apex or at the sides (Figs. 8 to 11). After conjugation, the nuclei of the two sporidia pass into the infection hyphae which become septate and prominently show the binucleate condition. In those cases in which the conjugation processes are formed from the equatorial region of the sporidia, an H-shaped connection is established as in many *Tilletia* species and the infection hypha is developed from the conjugation tube. On the other hand, when the sporidia fuse by their terminal ends, the nucleus and cytoplasm from one sporidium completely migrate into the other. In rare instances, the conjugation of more than two sporidia has also been observed. In one case, three sporidia had conjugated with one another, but the infection hyphae that had formed possessed only two nuclei, while the nucleus of the third sporidium was lagging behind and probably became non-functional (Fig. 12).

Germinating spores were used for inoculating the leaves of *Hygrophila* sp. in petri dishes according to the method adopted by Clinton and McCormick (1924). The leaves could be maintained in the dishes only for 12 to 15 days. However within that time, the inoculated leaves showed the infection spot gradually expanding into a yellow patch, resembling in all respects those which occur in naturally infected leaves. In artificial inocu-



FIGS. 8-12. Conjugation of sporidia,  $\times 1000$ . FIG. 13. Development of conidiospores on the secondary mycelium,  $\times 1800$ .

lation experiments, stages up to the development of the spore balls could not be followed, because the vigor of the host leaves gradually diminished.

In some of the germinating spores, the infection hyphae developing after sporidial conjugation had produced limited branching hyphae. It was observed that some of these had formed laterally somewhat allantoid to arcuate spores. These are probably (Fig. 13) of the same nature as the falcate conidia borne on the secondary mycelium of species of *Tilletia*. This type of conidia has, as far as the author knows, not been described for any



of the species of *Doassansia*. Further studies are being made to elucidate the nature of these secondary spores.

The structure and development of the sori indicate that the species of *Doassansia* under consideration belongs to the subgenus *Eudoassansia* of Setchell. Among the species of *Doassansia* found on various Sympetalae with which the present species could be compared might be mentioned *Doassansia Downingiae* Liro on *Downingia elegans* (Lobeliaceae) described by Liro (1935) and *D. Rhianthi* Lagerh. described recently by Zundel (1944) on *Rhianthus* (Scrophulariaceae). Comparative studies indicate that the two smuts referred to above are quite different from the species occurring on *Hygrophila*. The dark brown opaque spore balls with reddish-brown sterile cortex of *D. Rhianthi* and the thick-walled yellowish sterile cortex with punctate walls of *D. Downingiae* clearly differentiate them from the *Doassansia* species on *Hygrophila*. Furthermore, the spore measurements also show considerable variation, and there is little doubt that the *Doassansia* species on *Hygrophila* is new to science.

### *Doassansia Hygrophilae*, sp. nov.

Sori foliicolous, forming yellow spots gradually enlarging into orange-yellow patches, spots circular to irregular, 8 to 12 mm. wide, with minute pustulate specks arranged concentrically indicating the position of the spore balls. Spore balls permanently embedded in the mesophyll tissue, occupying the entire space between the upper and lower epidermis, globose to polygonal due to pressure against one another, often confluent, 120 to 200 $\mu$  in diam. Cortex distinct, cortical cells conspicuous, radially elongate, 16.5–25 $\times$ 9–15 $\mu$ ; rounded at both ends, cinnamon-yellow, smooth and vacuolate; spore mass completely filling the interior, individual spores loosely packed, pale cinnamon-yellow, subglobose to angular on account of lateral compression, thin-walled, smooth, 10–15 $\mu$  in diam. with a mean of 12.2 $\mu$ . Spores germinating with one or rarely two-septate promycelia bearing a terminal whorl of 5 to 7 sporidia, spreading out in a radiating manner; mature sporidia fusiform, broader at the base than at the apex, asymmetric, measuring 14–16 $\times$ 1–1.2 $\mu$ , forming secondary sporidia acrogenously, and conjugating after separation from the promycelium.

*Habitat*: On the leaves of *Hygrophila* sp. Nandi Hills, Mysore State, India, 5-11-1944, leg. M. J. Thirumalacher; type deposited in the Herb. Crypt. Ind. Orient., New Delhi and at the Imperial Mycological Institute, Kew, England.

Sori foliicoli maculas luteas gradatim crescentes in aurantiaco-luteos textus plus minus circulares vel irregulares 8–12 mm. diam. formantes pustulis minutis concentrice dispositis atque sporarum positionem indicantibus. Sporarum sphaericae massae permanenter in mesophyllo infixae, simul aggregatae, totum spatium inter superiorem et inferiorem foliorum

faciem occupantes, globosae vel angulares, saepe confluentes, 120-200 $\mu$  diam. Cortex distinctus; cellulae corticales conspicuae, radialiter elongatae, 16.5-25 $\times$ 9-15 $\mu$  diam., in utroque apice rotundae, cinnamomeo-luteae atque laeves. Sporae totum spatium occupantes, haud arcte aggregatae, pallidae cinnamomeo-luteae, subglobosae vel angulares, tenuibus parietibus praeditae, laeves, 10-15 $\mu$  diam. (med. 12.2 $\mu$ ). Sporae efformato promycelio 5-7 sporidiis verticillatis radialiter divaricatis germinantes; matura sporidia fusiformia, basi latiora quam apice, asymmetrica, 14-16 $\times$ 1-1.2 $\mu$ , secundarium vel tertiarium sporidium acrogene efformantia, atque bina post separationem ex promycelio conjugantia.

*Habitat*: in foliis *Hygrophilae* sp., Nandi Hills, in regione Mysore, 5-11-1944, legit M. J. Thirumalachar. Typus positus in Herb. Crypt. Ind. Orient., New Delhi atque in Imperial Mycological Institute, Kew, Anglia.

The writer wishes to express his indebtedness to Dr. B. B. Mundkur, Imperial Agricultural Research Institute, New Delhi, to Dr. L. N. Rao, Professor of Botany, University of Mysore, for helpful suggestions and encouragement, and to the University of Mysore for the award of the Research Fellowship. Rev. Father Dr. H. Santapau, Ph.D., S.J., Professor of Botany, St. Xavier's College, Bombay, kindly rendered the diagnosis of the new species into Latin.

#### LITERATURE CITED

- BIRAGHI, A. 1934. Ricerche citologiche sul processo di germinazione delle clamidospore di "Urocystis tritici" Koern. Boll. R. Staz. di Patologia Vegetale **14**: 1-19.
- CORNU, M. 1883. Sur quelques ustilaginées nouvelles ou peu connues. Ann. Sci. nat. Bot. VI **15**: 269-296.
- CLINTON, G. P. AND F. A. McCORMICK. 1924. Rust infection of leaves in Petri dishes. Connecticut Agri. Exp. Sta. Bull. **260**.
- DANGEARD, P. A. 1894. Recherches sur la reproduction sexuelle des champignons. Le Botaniste **3**: 221-81. (Original not seen.)
- FISCH, C. 1884. Entwicklungsgeschichte von *Doassansia Sagittariae*. Ber. deuts. bot. Ges. **2**: 405-16. (Original not seen.)
- LIRO, J. I. 1935. Über neue, seltene und vermeinte Ustilagineen. Ann. Bot. Soc. Zool-Bot. Fennicae Vanamo **6**: 2. (Original not seen.)
- LUTMAN, B. F. 1910. Some contributions to the life history and Cytology of smuts. Trans. Wisconsin Acad. Sci., Arts & Letters **16**: 1191-1244.
- MUNDKUR, B. B. 1940. A second contribution towards a knowledge of Indian Ustilaginales. Fragments XXIV-L. Trans. Brit. Mycol. Soc. **24**: 312-36.
- RAWITSCHER, F. 1922. Beiträge zur Kenntnis der Ustilagineen II. Zeit. f. Bot. **14**: 273-296.
- SETCHELL, W. A. 1892. An examination of the species of the genus *Doassansia* Cornu. Ann. Bot. Lond. **6**: 1-48.
- THIRUMALACHAR, M. J. 1940. A method for germinating and staining teleutospores. Journ. Ind. Bot. Soc. **19**: 70-75.
- ZUNDEL, G. L. 1944. Notes on the Ustilaginales of the world IV. Mycologia **36**: 400-412.



# Four Marine Algae from Australia and New Zealand<sup>1</sup>

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The four species of marine algae treated in the following pages are represented among the collections made by Professor J. E. Tilden and a group of graduate students (South Pacific Plants, Series II, 1934-1935). Two of them, *Acrosorium uncinatum* and *Phytymorphora imbricata*, have been known for years, but are included here, because additional information and accurate figures seem desirable. The other two, *Ceramium nanum* and *Ectocarpus Warnocki*, are described as new.

The author takes this opportunity to express his gratitude and indebtedness to Dr. H. Kylin, Sweden; Dr. H. E. Petersen, Denmark; and the late Professor R. M. Laing, New Zealand, for needed reprints; to Dr. Juergens, Germany; and Dr. H. A. Hill, California, for transcriptions from books otherwise inaccessible; and, finally, to Professor J. E. Tilden, not only for the plant material here described, but also for whatever knowledge he possesses of marine algae.

## ACROSORIUM UNCINATUM (J. Ag.) Kylin

*Acrosorium uncinatum* (J. Ag.) Kylin, Studien Deless. 78, fig. 61. 1924; *Nitophyllum uncinatum* (Turn.) J. Ag. Spec. gen. et ord. alg. 2 (2): 654. 1852; *Cryptopleura lacerata* var. *uncinata* Kuetz. Tab. phyc. 16: 10. pl. 25e. 1866; *Areolaria cristata* Schousboe, Bornet Les alg. de P. K. A. Schousboe, 294. 1892.

*Acrosorium uncinatum*, long known as *Nitophyllum uncinatum*, is a truly cosmopolitan plant. It has been reported from Great Britain (Cotton, Newton); the Mediterranean coasts of France, Italy and Spain, and the Atlantic coasts of France and Great Britain (J. Agardh); Tanger Bornet; Cape of Good Hope (De-Toni); New Zealand (Cotton, Laing); Australia (Harvey, Lucas, Wilson); Dutch East Indies (Weber van Bosse); and is widely distributed on the Pacific coast of Japan (Okamura, Takamatsu). In the United States it has only been reported from San Diego and San Pedro in California, sometimes in such quantities as to "clog the nets of fishermen" (Nott). G. M. Smith informs me<sup>2</sup> that the University of California possesses herbarium specimens from several other localities, all of them lying in the algal area that Setchell designated as subtropical. He also states that, at La Jolla, the plant is a very common epiphyte on *Gelidium*, *Pterocladia*, and various other algae, especially late in the summer.

<sup>1</sup> Excerpts from a thesis presented to the Graduate School of the University of Minnesota under the title "Some Contributions to the Knowledge of the Marine Algae of Australia and New Zealand."

<sup>2</sup> Personal communication, June 21, 1944.

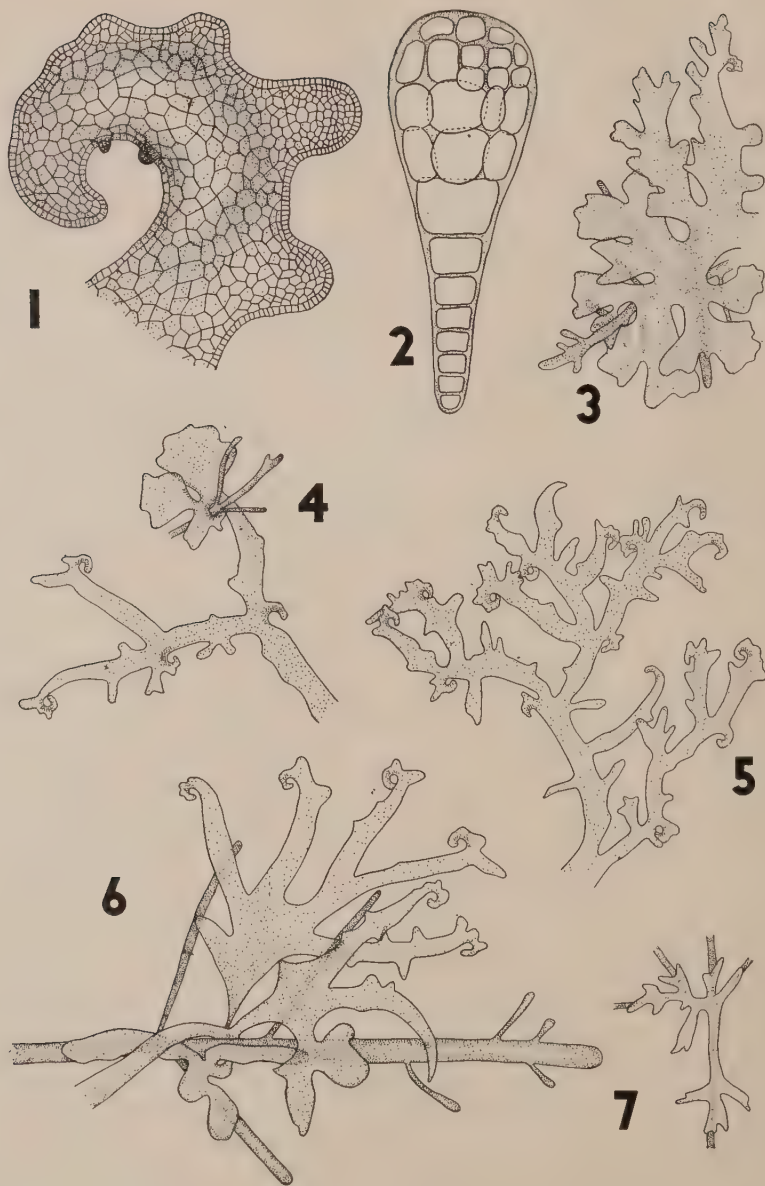


PLATE 1. *Acrosorium uncinatum*. 1. Surface view of hook (magnified). 2. Cross section through hook (magnified). 3. Thallus of expanded growth upon *Gelidium capillaceum*, one edge showing formation of hook ( $\times 1$ ). 4. Portion of plant showing wedge-shaped segments. 5. Thallus consisting entirely of hooked formations ( $\times 1$ ). 6. One hook clasped a *Gelidium* segment; some segments growing in hooked formation, others in linear form along the *Gelidium*. 7. Portion of thallus of very small size ( $\times 1$ ). (Figs. 1-7 after Nordhausen; all others original)



This cosmopolitan distribution may account for the great variability in the vegetative structure of the plant. Nott's detailed synopsis shows this to be true for the Californian plants. Nordhausen, who made a detailed study of the growth habits of the Mediterranean plants (Figs. 1-7), concluded that, in extreme cases, it is rather difficult to draw a sharp line of demarkation between this and other species of *Nitophyllum* (to which genus the plant was referred in his days). And Kylin<sup>3</sup> believes that at least the individuals from the Mediterranean, from California and Australia, are distinct varieties of *Acrosorium uncinatum*.

The plants collected by I. B. Warnock at Point Lonsdale, Victoria, Australia, agree well with the general descriptions of Nott and Nordhausen. The fronds are all of the erect type. The sessile portion of the thallus is small and almost disk-like. From it arise two or three linear branches which, in turn, give rise to new segments. The whole thallus is delicately membranaceous and consists, except in the veins, of a single layer of cells. Neither a midrib nor conspicuous veins are present. But delicate, microscopic veins extend throughout the entire frond, branch freely though irregularly in a dichotomous manner, and frequently anastomose. They arise through subsequent divisions of regular thallus cells into 3-5 daughter cells, all lengthened in longitudinal direction and lying parallel to the surface. They do not project above the surface, and in the hooked segments they terminate as described by Nordhausen (Fig. 10). Apical growth is similar to that described by Kylin for *Cryptopleura lacerata*, and by Papenfuss for *Acrosorium acrospermum* (Fig. 12). But since other marginal cells may also develop into secondary initial cells, the manner of apical growth gradually becomes obscured (Fig. 20).

Rhizoids were observed only in the hooks, where they occur in clusters and in an immature condition (Fig. 10). All specimens were free from epiphytes and parasites, and sterile. Nott seems to be the only one to have found specimens with cystocarps, while J. Agardh was the first to report sporangia. But neither of these authors furnished drawings. Most collectors state that their specimens were sterile. Hence, Nott may be right when he says, "there is a strong probability that the plant propagates itself largely, if not entirely, by vegetative means."

The color of those specimens that have been kept away from the light (all of them preserved in formalin solution) is a bright rosy-red tint. The height of the fronds varies from 2-4 cm. Other collectors indicate greater variability, ranging between 2-6 cm. Mazza (1908) found that young plants varied from a few millimeters to 2 cm., and that several adult plants measured as much as 8 cm. Nott states that the fronds may attain a length of 10-15 cm.

The material was collected November 28, 1934. The attached label car-

<sup>3</sup> Personal communication, June 19, 1945.



PLATE 2. *Phytomorphora imbricata*. 8. Very young portion of thallus ( $\times 33$ ). 9. A sporophyll ( $\times 33$ ). *Acrosorium uncinatum*: 10. Hook, showing thickened inner half, bundles of rhizoids, microscopic veins ( $\times 20$ ). *Ectocarpus Warnockii*: 11. Portion of thallus ( $\times 33$ ).

ries the following note, "First zone of transect line (about as far out as one can get at low tide period), attached to coralline algae and eelgrass." It may be added that the oldest authors are satisfied with merely stating that the plant is epiphytic upon other algae (Bertoloni). Later ones mention definite substrata, such as *Zostera* (Ardissonne, Mazza), *Gelidium* (De-Toni, Nordhausen), *Bryopsis* and *Corallina* (Nordhausen), and *Phyllospadix* (Nott). The corallines, by reason of their jointed structure and rough surfaces, seem to furnish an excellent habitat.

PHITYMORPHORA IMBRICATA (Aresch.) J. Ag.

*Phitymophora imbricata* (Aresch.) J. Ag. Spec. gen. et ord. alg. 3 (3): 170. 1898; *Delesseria imbricata* Aresch. Phyc. novae. 346. 1854; *Delesseria rigida* Harvey Alg. exsicc. No. 276; *Chauvinia imbricata* Harvey Phyc. austr. Syn. cat. xxxi and pl. 240. 1862; *Delesseria amansioides* Sonder, Kuetz. Tab. phyc. 19: 4, 1868.

The primary frond is 8-12 cm. long and 4-4½ mm. wide, slightly stipitate, strictly linear, with an acute base and obtuse apex, the margin entire and more or less wavy, and with conspicuous midrib, but no lateral veins. From both sides of the midrib there arise, at brief but irregular intervals, secondary fronds of similar structure, which in their turn bear similar but smaller fronds (Fig. 13). This mode of ramification is repeated several times until there results, in the words of Harvey (1862), who had seen specimens in living condition, "a nearly globose, excessively compound general frond, whose leaflets are closely *imbricated* one on another." The primary frond is gradually changed into a compressed stem, consisting essentially of the thickened midrib. Dimensions of the larger secondary fronds 76-127 × 12-19 mm.

As to the cellular structure, the fronds, with the exception of the midrib, when viewed superficially, seem to be made up of three layers. The middle layer consists of large, irregularly polygonal cells (Fig. 8), whereas the outer layers of smaller cells exhibit 8-12 of the latter to one of the former (Figs. 14, 17). Near the edge the fronds become reduced to a single layer of elongated cells. The midrib, of more than three layers, terminates in a single apical cell, from which cells are cut off transversely (Fig. 14). In the sporophylls the middle layer seems to be entirely wanting.

Since only dried material was available, it was impossible to study the internal structure of the fronds in detail. The structure of the disk has been described by Mazza (1922).

Sporangia are borne on special minute sporophylls which are round or slightly obovate in shape and 2-4 mm. in diameter. Like the proliferations the sporophylls arise from the midrib. The sporangia are not scattered over these minute leaflets, but aggregated into sori, which develop on each side of the midrib and gradually cover the greater part of the sporophyll surface (Fig. 9). The collection did not contain specimens with cystocarps.



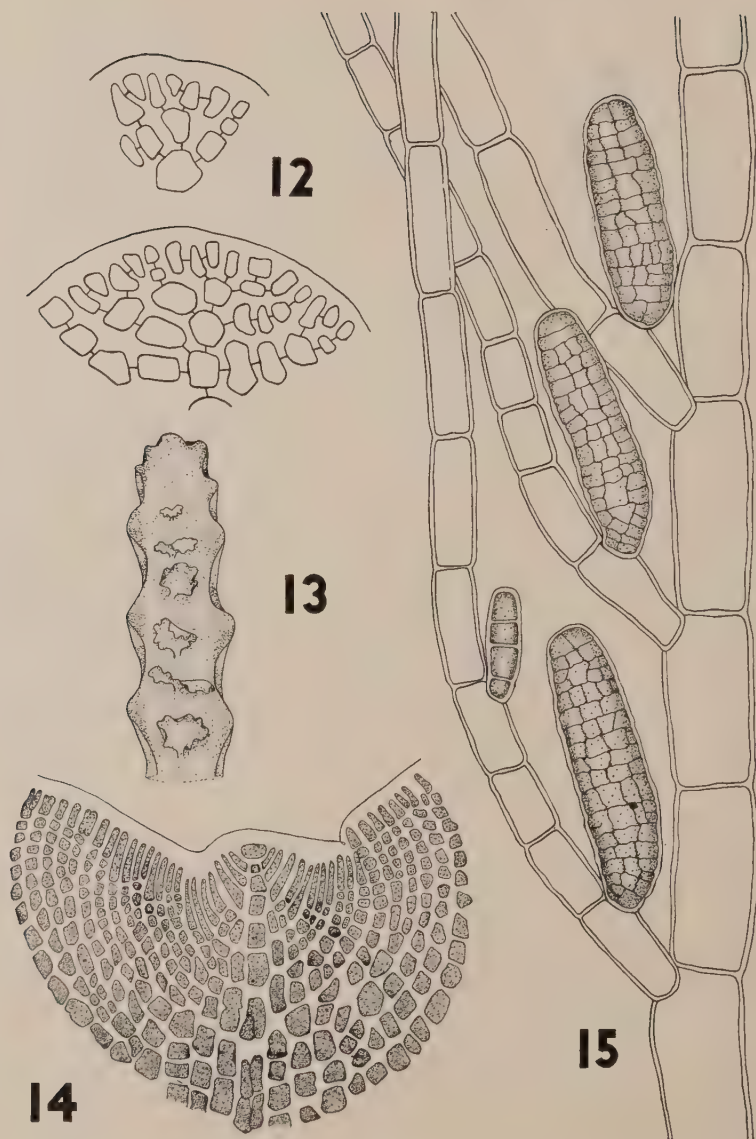


PLATE 3. *Acrosorium uncinatum*. 12. Manner of apical growth ( $\times 500$ ). *Phytomorpha imbricata*: 13. Portion of linear frond, bearing six rounded leaflets ( $\times 5$ ). 14. Tip of small frond, showing definite mode of growth ( $\times 400$ ). *Ectocarpus Warnockii*: 15. Plurilocular reproductive organs ( $\times 400$ ).

Harvey informs us that the cystocarps are likewise produced on the mid-ribs of special minute leaflets, and are "hemispherical, thick-walled, containing a nearly globular tuft of moniliform sporethreads."

The specimens (South Pacific Plants, II, No. 99) were collected by Miss C. M. Crosby at Point Lonsdale, Victoria, Australia, November 20, 1934. They were dark or blood red in color when alive and became darker in drying. In the dry state they do not adhere to the paper. *Phytomorpha imbricata* is not only a strictly Australian, but also highly localized species, having thus far been reported only from Port Phillips Heads and vicinity. Another species, *Ph. linearis*, is endemic in New Zealand.

#### NOTE ON A NEW SPECIES OF CERAMIUM

The genus *Ceramium* was established by C. A. Agardh in 1817; but already in 1849 Harvey (Ph. Brit. 2: 181) was forced to admit, "the *Ceramia* are almost as unsatisfactory to the Botanists as the *Rubi*, and their varieties quite as numerous." To a large extent this difficulty was due to the fact that the species constituting the modern genus *Ceramium* were distributed among several other genera. J. Agardh (1894) tried to remedy this confusion by collecting all forms under the single generic term *Ceramium*, grouping them into various tribes and using the old generic names for this purpose.

The measure, however, proved only partially successful, and the genus is taxonomically as difficult as ever. Many early accounts are of very little value because of inadequate descriptions or uncertain synonymy. Sometimes, too, drawings are either entirely wanting or so poorly executed as to be of little help. The added fact that, in several instances, the type material can no longer be located, easily explains why taxonomists hesitate to create new species.

In spite of this, the *Ceramium* collected at the Bay of Islands, New Zealand, is here described as new. The verticillate arrangement of the sporangia places it in Agardh's series *Periclinia*; its corticated zone, a definite ring with no apparent growth from either the upper or lower margin, in the tribes *Leptogonia* or *Brachygonia*. The fact that the lower portion of the sporangium remains immersed in the cortical zone and only the upper protrudes, limits it to the last named tribe. In the structure of its cortication it agrees well with that of *C. diaphanum* as shown by Petersen (1911, fig. 1); but differs from it in all other respects. Thus its apices are straight, not hooked; the involucrel ramuli surrounding the cystocarps are long; the filaments are considerably narrower toward the base; the corticated zones are not as high as broad. Similar differences exist also between the new species and others belonging to this tribe.

***Ceranium nanum*, sp. nov.**

Fronde pusilla, 5-10 mm. longa; regulariter dichotoma, ramis lateralibus e zonis surgentibus rare instructa; apice simplici, rarius bifurcato (in ramellis juvenilibus); setis et pilis copiosis; filamentis inferne 150-180 $\mu$  latis, gradatim sursum angustioribus; cellulis superne paule altioribus quam latis, ad basim vix aequae altis ac latis; interstitiis ad apicem valde angustis, ad basim circiter aequae altis ac zonis; corticatione zonis interrupta; zona corticale latiore quam alta, 2-3 series cellularum rotundato-angularum irregulariter positarum gerente; sporangiis in ramulis superioribus ad genicula verticillatim numero vario dispositis, elliptico-oblongiis, superiore sua parte fere ex toto emergentibus nudis, strato hyalino circumdati, triangle divisa, circiter 28-33 $\times$ 40-65 $\mu$  (membrana 5-7 $\mu$  exclusa); cystocarpiis rotundatis, singulis, nonnumquam 2-3, 196-259 $\mu$  latis, in ramis superioribus sessilibus; involucris ramellis pluribus, 3-5, cystocarpium longe superantibus.

Frond small, 5-10 mm. high; branching regularly dichotomous; lateral branches rarely arising from the nodes; apices simple, rarely forcipate (in branchlets); setae and hairs abundant; filaments 150-180 $\mu$  broad near base, becoming gradually more narrow above; axillary cells somewhat longer than broad near the apex, scarcely as high as broad near the base; cortication restricted to nodes; corticated zones broader than high, composed of 2-3 layers of irregularly placed, roundish-angular cells; sporangia verticillate in nodes of upper branches, elliptical or oblong, with upper portion almost entirely extruding, surrounded by a hyaline membrane 5-7 $\mu$  in thickness, 28-33 $\times$ 40-65 $\mu$  (exclusive of membrane); cystocarps round, single, sometimes 2-3, 196-259 $\mu$  broad, on upper branches, surrounded by 3-5 very long involucre branches.

On flat rocks. Oneroa, near Russell, Bay of Islands, New Zealand. Jan. 25, 1935. Collector Irl B. Warnock. (South Pacific Plants, II. No. 485.)

To the above description the following remarks may be added. The dichotomous ramification produces a more or less bilateral, somewhat dorso-ventral thallus, whose apices are generally straight (Figs. 21, 22). The cortical cells are arranged in definite layers (2-3) at the nodes. The outer layer consists of small, roundish or angular cells. The inner is composed of angular cells, larger and less numerous than those of the outer layer (Fig. 23). The nodes, of which there are 4-6 in each ramification, are always wider than high, and commonly only slightly protruding.

Delicate hyaline hairs, 250-400 $\mu$  long, are plentiful. Setae are found on all corticated zones, arising only from the upper margin of each zone (Fig. 22). They are less than 64 $\mu$  in length, and not more than 3.5 $\mu$  in width.

The specimens were abundantly fructiferous. The sporangia form a whorl in the corticated zones of the upper, but not ultimate branches (Figs.





PLATE 4. *Ceramium nanum*. 16. Portion of sporophyte ( $\times 93$ ). *Phytomorphora imbricata*:  
17. Apical portion of frond ( $\times 381$ ).

16, 19), and are surrounded by a conspicuous hyaline membrane. The cystocarps are sessile at the nodes of the upper branches (Pl. 6) and surrounded by 3-5 elongated unbranched involucrel ramuli (Fig. 23). There were only fragments of spermatangial specimens. The spermatangia occur in patches of various sizes at the nodes (Fig. 18).

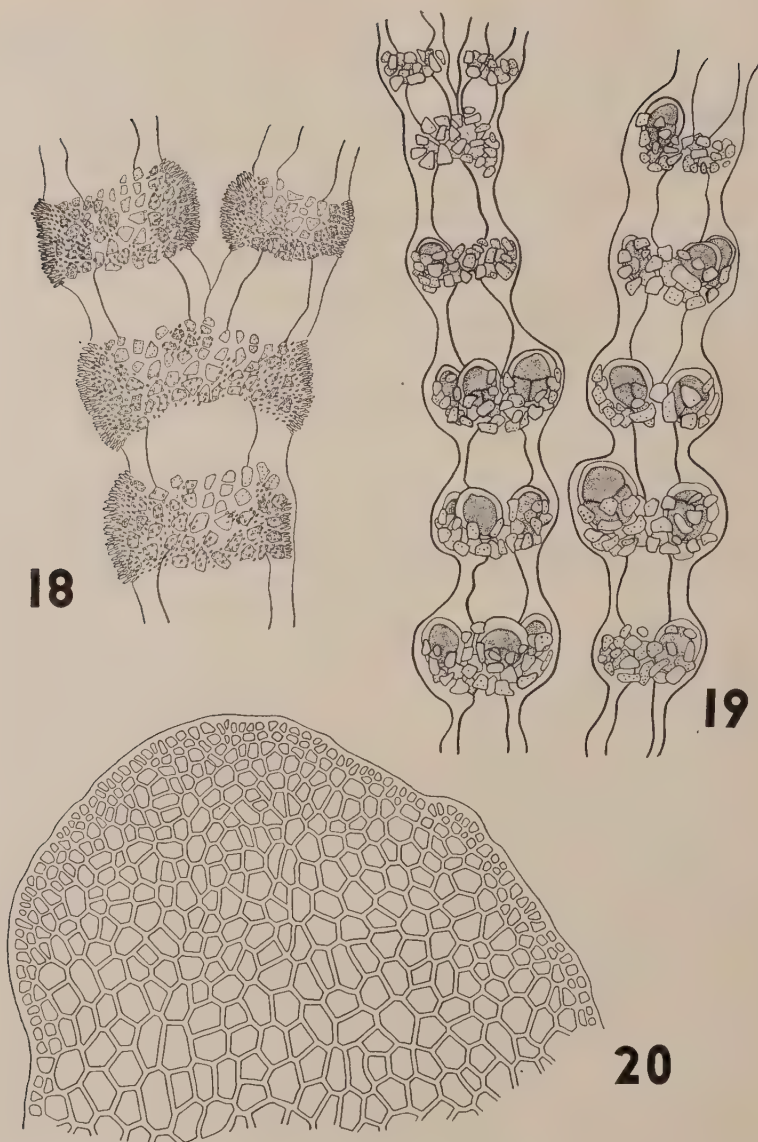


PLATE 5. *Ceramium nanum*. 18. Portion of male gametophyte; only upper layer of cortication shown ( $\times 200$ ). 19. Portion of sporophyte ( $\times 200$ ). *Acrosorium uncinatum*. 20. Tip of frond ( $\times 200$ ).

#### NOTE ON A NEW SPECIES OF ECTOCARPUS

Among the plants collected at the Bay of Islands, New Zealand, an *Ectocarpus* was found growing intermingled with *Ceramium nanum*. In the size and structure of the plurilocular reproductive organs it agrees quite

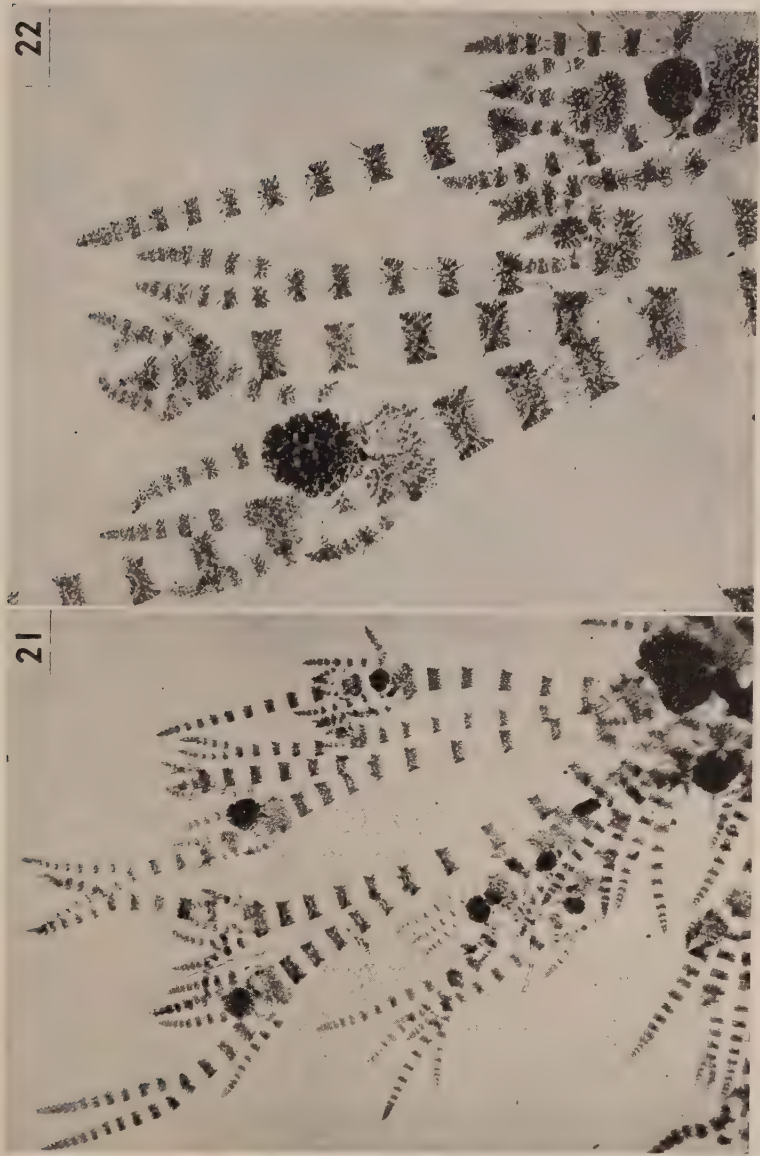


PLATE 6. *Ceramium nanum*. 21. Portion of female gametophyte ( $\times 33$ ). 22. Section of the previous, enlarged to show setae and hyaline hairs ( $\times 93$ ).



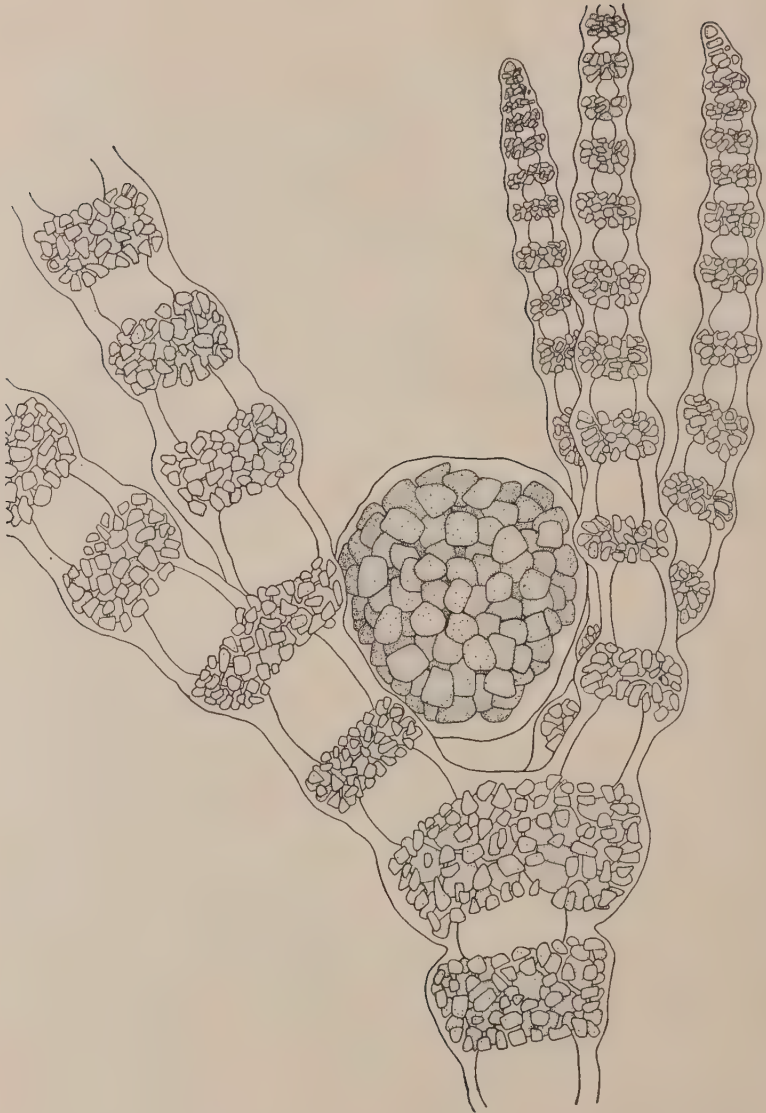


PLATE 7. *Ceramium nanum*. 23. A cystocarp with its involucreal ramuli ( $\times 200$ ).

well with that found in Australia and described and figured by Askenasy (1894) as *Ectocarpus Indicus* Sonder. In the size of the thallus, however, it differs considerably. Sonder's diagnosis states "bipolycaris vel ultra," and Askenasy's specimens were up to 2 cm. long. The plant in question, however, is only minute. Of course, such a difference might perhaps be ascribed to the geographic remoteness and somewhat different climatic conditions

of New Zealand. But there is also the added difference in the general manner of branching. According to Askenasy and De Toni (1895) *E. indicus* branches irregularly in all directions. In the New Zealand specimens the branching is mostly subsecund.

A search through the literature has failed to reveal any other species to which the plant might be referred. Differences are not only to be found in the general growth habits of the thallus and the size and shape of the chromatophores, but especially in the size and shape of the reproductive organs. The plant is therefore described as new, since it was also found in intimate association with another new species, *Ceramium nanum*.

### ***Ectocarpus Warnocki*, sp. nov.**

Fronde caespitosa, 6–10 mm. alta; filis primariis usque ad  $35\text{--}42\mu$  latis; fronde, basi modice ramosa, superne ramosissima; ramis subsecundis, nonnumquam alternis, saepe in pilum abeuntibus; articulis cylindraceis, ad genicula leviter constrictis; chromatophoris discoideis; gametangiis numerosis, cylindraceis,  $17\text{--}32 \times 37\text{--}147\mu$ , sessilibus, secundatim in ramis superioribus dispositis.

Frond caespitose, 6–10 mm. high; main axis up to  $35\text{--}42\mu$  broad; frond sparsely branching in lower portion, profusely in upper, in a subsecund, sometimes alternate manner; branches often terminating in a hair; cells cylindrical, slightly constricted at transverse walls; chromatophores discoid; plurilocular reproductive organs numerous, cylindrical,  $17\text{--}32 \times 37\text{--}147$  mic., sessile, secund on upper branches.

On flat rock. Oneroa near Russell, Bay of Islands, New Zealand. Jan. 25, 1935. Collector, Irl B. Warnock. (South Pacific Plants, II. No. 485.)

The plant (Fig. 11) was found growing on rocks, attached by means of rhizoids. These, however, are only poorly developed. A main axis may be distinguished. It is about  $12\text{--}18\mu$  broad near the base, and rapidly increases in thickness to about  $35\text{--}42\mu$ . Branches do not arise from every cell. Generally, several cells forming branches are followed by a longer or shorter row of cells without branches. Most branches terminate in a hair; that is, in a row of elongated empty or colorless cells. The cells are cylindrical and slightly constricted at the transverse walls (Fig. 15). In the main axis their length is 1–2 times their width. In the branches the cells are generally slightly longer than broad near the stem, but gradually increase in length and decrease in width (especially in the hairs). The chromatophores are discoid, small and numerous. They are to be found in all cells, except those constituting the hairs.

All specimens were abundantly fructiferous. The plurilocular reproductive organs are sessile and secund on the upper branches, cylindrical and very variable in size (Fig. 15).

## BIBLIOGRAPHY

- AGARDH, C. A. *Synopsis algarum Scandinaviae, adjecta dispositione universali algarum*. Lund. 1817.
- AGARDH, J. G. *Species, genera et ordines Floridearum*. Sp. gen. et ord. alg. **2** (1) 1851; (2) 1852; (3) 1863.
- *Analecta algologica. Observationes de speciebus algarum minus cognitiss earumque dispositione. Continuatio 2*. Lund. 1894.
- *De dispositione Delesseriarum*. Sp. gen. et ord. alg. **3** (3). 1898.
- ARDISSONE, F. *Phytologia Mediterranea*. Varese. 1883. 1886.
- ARESCHOUG, J. E. *Phyceae novae et minus cognitae in maribus extra-europaeis collectae*. Nov. Act. Reg. Soc. Sci. Series III. **1**: 329-372. 1854.
- ASKENASY, E. *Ueber einige australische Meeresalgen*. Flora **78**: 1-18. pl. 1-4. 1894.
- BERTOLONI, A. *Amoenitates italicae*. Bononiae. 1819.
- BORNET, A. Les algues de P. K. A. Schousboe, recoltées au Maroc et dans la Méditerranée de 1815 à 1829. *Mém. Soc. Nat. Sci. et Math. de Cherbourg* **28**: 165-376. pl. 1-3. 1892.
- COTTON, A. D. *Notes on New Zealand marine algae*. Bull. Misc. Inform. Roy. Bot. Gard. Kew **1909**: 239-243.
- DE-TONI, J. B. *Sylloge algarum*. **4** (1-4): Florideae. 1897. 1900. 1903. 1905.
- HARVEY, W. H. *Phycologia Britannica, or A history of British seaweeds*. London. **1**: 1-120. 1846; **2**: 121-240. 1849; **3**: 241-360. 1851.
- *Phycologia australica, or a history of Australian seaweeds and a synopsis of all known Australian algae*. **1**: i-lxxiii. pl. 1-60. 1858; **2**: pl. 61-120. 1859; **3**: pl. 121-180. 1860; **4**: 181-240. 1862.
- KUETZING, F. T. *Tabulae phycologiae, oder Abbildungen der Tange*. 19 volumes and Index. 1900 plates. Nordhausen. 1845-1871.
- KYLIN, H. *Studien ueber die Delesseriaceen*. Lunds Univ. Årsskr. N.F. **20** (6): 1-111. Figs. 1-80. 1924.
- LAING, R. M. *Revised list of New Zealand seaweeds. Part II*. Trans. and Proc. New Zealand Inst. **34**: 327-359. 1901.
- *A reference list of New Zealand marine algae*. Trans. and Proc. New Zealand Inst. **57**: 126-185. 1926. Suppl. I. Ibid. **60**: 575-583. 1929.
- LUCAS, A. H. S. *Revised list of the Fucoideae and Florideae of Australia*. Proc. Linnean Soc. New South Wales **34**: 8-60. 1909.
- MAZZA, A. *Saggio di algologia oceanica. La nuova Notarisia* **19**: 46-66. 1908.
- *Aggiunte al saggio di algologia oceanica*. Ibid. **33**: 1-31. 1922.
- NEWTON, L. *A handbook of the British seaweeds*. London. 1931.
- NORDHAUSEN, M. *Zur Anatomie und Physiologie einiger rankentragender Meeresalgen*. Pringsheim's Jahrb. fuer wiss. Bot. **34**: 236-278. pl. 8. 1900.
- NOTT, C. P. *Nitophylla of California*. Proc. Calif. Acad. Sci. III Botany, **2**: 1-62. pl. 1-9. 1900.
- OKAMURA, K. *Icones of Japanese algae*. **1**: 1-258. 1907-1909.
- *Nippon Sorue Mei* (In Japanese). 2nd ed. 1916.
- *On the algae from the island Hatidyo*. Records Ocean. Works Japan **2**: 92-110. pl. 6-10. 1930.
- PAPPENFUSS, G. F. *The development of the reproductive organs in Acrosorium acrospermum*. Bot. Notiser **1939**: 12-20. Figs. 1-30.
- PETERSEN, H. E. *Ceramium Studies I and II*. Bot. Tidsskr. **31**: 97-120. pl. 1-5. Text fig. 1-6. 1911.
- TAKAMATSU, M. *The marine algae from Matsushima Bay*. Saito Ho-on Mus. Res. Bull. **8**: 1-43. pl. 1-2. 1936.
- *Marine algae from the coast of Japan Sea in Northeastern Honshu*. Ibid. **17**: 21-83. pl. 5-13. 1939.
- WEBER VAN BOSSE, MME A. *Liste des algues du Siboga*. **59**: 1-533. pl. 1-16. Text figs. 1-212. Leiden. 1913-1925.
- WILSON, J. B. *Catalogue of algae collected at or near Port Phillips Heads and Western Port*. Proc. Roy. Soc. Victoria. N.S. **4**: 157-190. 1892.



# The Taxonomy of Godoya R. and P., Rhytidanthera van Tieghem, and Cespedezenia Goudot (Ochnaceae)

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In two recent papers dealing with the tribe Luxemburgieae<sup>1</sup> I pointed out that the following genera: *Godoya* R. and P., *Rhytidanthera* van Tieghem, *Cespedezenia* Goudot, *Krukoviella* A. C. Smith, *Blastemanthus* Planchon, and *Luxemburgia* St. Hil. form a complex within the tribe, suggesting that of this group the first four genera exhibit even a more striking alliance. I propose here to discuss the taxonomy of the first three of these allied genera,<sup>2</sup> having already treated the genus *Krukoviella* in a separate paper. The species of *Godoya*, *Rhytidanthera*, and *Cespedezenia* are arboreal, with the exception of one species of *Rhytidanthera*, *R. sulcata* van Tieghem, which is described as a shrub. The eleven species of this trio of genera are all confined to tropical America. Structural similarities between the genera are especially manifest in their bracts, flowers, and fruits. In the *Fleurydora* paper cited below I stated that "... the sepals of *Rhytidanthera*, the only pinnately-leafed genus of the Ochnaceae, are the prototypes of those of *Godoya* in every detail. This character, as well as less obvious characters, demonstrate the close relationship existing between *Godoya* and *Rhytidanthera*. Both of these are closely allied with the genus *Cespedezenia* Goudot principally on the basis of the following characters: the fimbriate appendages (glands?) located at the proximal and inner surface of the bracts and sepals, the coriaceous and estylate and pentacarpellate pistil with intrusive T-shaped parietal placentae and with sessile radiating stigmas, and lastly the distinctly alate seeds." *Rhytidanthera* is readily distinguished from *Godoya* and *Cespedezenia* by its compound leaves while *Godoya* and *Cespedezenia* are easily separable, the former genus having 10 stamens and deciduous stipules, the latter having very numerous stamens and persistent stipules.

## USES AND NATIVE NAMES

In his treatment of the genus *Godoya* Planchon notes that *G. antioquiensis* is called "Counso" and *G. obovata* R. and P. is known commonly as

<sup>1</sup> A Discussion of the Ochnaceous Genus *Fleurydora* A. Chev. and the Allied Genera of the *Luxemburgieae*. Bull. Torrey Club 71: 175-178. 1944. The Taxonomy of the Genus *Krukoviella*. Torrey 45: 69-72. 1945.

<sup>2</sup> This paper represents a segment of a thesis on the *American Genera of the Tribe Luxemburgieae* (Ochnaceae), submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, Biological Laboratories, Fordham University Graduate School, New York, N. Y.

"Laupe," both species supplying very durable wood. Archer on his collection 305 of *G. antioquiensis* records the common name "Caunce." *Rhytidanthera magnifica* (Gleason) Dwyer and *R. sulcata* van Tieghem provide wood suitable for axles and gears, the former species, according to a notation on the type collection, being known locally as "Asuseno." Little information concerning the uses and native names of the six species of *Cespedezia* has been compiled. Goudot states that his species *C. Bonplandi* (= *C. spathulata* (R. and P.) Planch.) is known to the inhabitants of Colombia as "Lingua de Vaca" (Cow's tongue) or "Lingua de Buey" (Bull's Tongue), the descriptive names referring to the characteristic shape of the leaf-blades. On his collection 6357 (US) of *C. spathulata* from San Lorenzo, Esmeraldas, Ecuador, Little appends two local names: "Sajo," and "Pacora," while Gill records the name "Amarron-Gaspi" on two sterile collections (39 and 40) of probably *C. spathulata*, made at Napo Pastaza, Oriente, Ecuador. According to Gill's label this species is used in this area as an emetic in malaria therapy. Lawrance notes on his collection 618 of *C. repanda* from the El Humba region of Colombia that its local name is "Polbillya." In British Guiana, according to notations made on several collections *C. spathulata* is known as "Ariwa," "Hooboodiballi," and "Mungwagwa."

#### ACKNOWLEDGEMENTS

Specimens cited in this paper are deposited in herbaria of the institutions listed below, the customary symbol being employed in designating the particular institution.

Chicago Natural History Museum (F)

Gray Herbarium (G)

Royal Botanic Garden (K)

New York Botanical Garden (NY)

Museum d'Histoire Naturelle, Paris (P)

United States National Herbarium (US).

Throughout the paper an additional symbol *s. no.* is used in citing specimens bearing no collection number. I wish to express my appreciation to the directors of the above institutions who by their cooperation made this study possible. Special thanks are due to Dr. A. C. Smith of the Arnold Arboretum for his assistance and to Mr. Charles Gilly who prepared the plates and offered valuable advice.

#### KEY TO THE GENERA

Leaves Simple

Stipules of leaves deciduous; sepals large, unequal; stamens 10.....1. *Godoya*.

Stipules of leaves persistent; sepals small, subequal; stamens 50-75.....3. *Cespedezia*.

Leaves compound.....2. *Rhytidanthera*.

1. GODOYA R. and P. Fl. Per. Prodr. 1: 58. 1794.

*Godovia* R. and P. Per. Syn. 1: 467. 1805.

Trees; leaves sessile, simple, persistent at apices of branches, the secondary veins parallel and oblique-ascending, the tertiary veins perpendicular to secondary veins, dense, irregular, evanescent; stipules deciduous; inflorescences racemose or paniculate, the rachis terminal or axillary, the bracts with small basal and adaxial appendages, the latter gradually deciduous, the flowers solitary or fasciculate, the pedicels short, scarcely articulate; sepals 5, unequal, imbricate, spirally arranged, bearing small adaxial appendages at base; petals 5, bright yellow, distinctly unequal or subequal, exceeding sepals in length; stamens 10 in a single whorl around pistil, the anthers linear or narrow-elliptic, 4-celled, dehiscing by two terminal pores, the filaments short, almost as wide as anthers; pistil secund at anthesis, pentacarpellate, one-celled, short-stipitate, the stigmas 5, sessile, radiating, spongy, the ovary fusiform, the ovules very numerous, imbricate and in several rows on 5 intrusive T-shaped parietal placentae; fruit capsular, dehiscing septicidally, the margins of carpels separating from placentae, the latter filamentous, rough with persistent funiculi, the seeds oblong, transparent-winged, the wing subequal or obviously unequal at each end (Fig. 1.).

Type species: *Godoya obovata* Ruiz and Pavon.

#### KEY TO THE SPECIES

- Secondary veins of leaf-blades 0.9–1.4 cm. apart; leaf-blades usually drying lustrous orange-brown; petals 3.5–5 cm. long; Dept. Antioquia, Colombia.....1. *G. antioquiensis*.  
Secondary veins of leaf-blades 0.3–1.0 cm. apart; leaf-blades usually drying dull brown above; petals 2–3 cm. long; Peru and Bolivia.....2. *G. obovata*.

1. GODOYA ANTIOQUIENSIS Planch. Lond. Jour. Bot. 5: 598. 1846.

Trees up to 10 m. high, the trunk simple, densely branched at crown; leaf-scars large, fosseate, subrotund, 2.5–5 mm. long, about 5 mm. wide; leaf-blades lustrous-green, drying lustrous orange-brown, coriaceous, widely obovate-oblong, 8.5–17 cm. long, 3.5–8 cm. wide, obtuse to vaguely triangular at apex, cuneate at base, the margin vaguely serrate, the teeth minute, up to 0.3 mm. long, 0.2–1.3 cm. apart, the costa subplane above and below (except at base), up to 3.5 mm. wide, tapering and usually irregular at apex, the secondary veins 14–17 (rarely 19), 0.9–1.4 cm. apart, subprominent above, prominent beneath, simple or bifurcating in middle or close to margin, parallel-ascending, spreading from costa at 65°–70° angle; stipules deciduous; flower buds 2–3 cm. long, 0.8–1.3 cm. wide; inflorescence terminal, paniculate, the flowers solitary or frequently 2–3 per fascicle, the rachis 10–20 cm. long, usually exceeding uppermost leaves at anthesis, the pedicels stout, 0.6–2 cm. long, the articulation stalk 0.2–0.5 cm. long, the disc prominent; sepals unequal, concave, coraceous, strigose,



oblong-rotund, oblong or subrectangular, 1.0–2.2 cm. long, longer than wide, wide-triangular or obtuse at apex, often splitting irregularly, the sinuses 0.3–1 cm. deep, the margin entire, subinvolute; petals bright yellow, unequal or subequal, wide-oblong or oblong-rotund, 3.5–5 cm. long, 2.2–3.5 cm. wide, triangular or subobtuse at apex, obtuse to spatulate at base, the filaments 1–3 mm. long; ovaries smooth or striate, narrowly fusiform, 1.5–2 cm. long, the stigmas 5; capsules smooth, the lobes distinct, coriaceous, drying dark-brown, linear-falcate (here indehiscent), up to 7 cm. long, 0.45 cm. wide, the seeds about 2 mm. long, up to 0.65 mm. wide, the wings unequal, 3.7–4.7 mm. long (Fig. 1, g, h).

Type locality: High Mountains, Dept. Antioquia, Colombia.

Illustration: Planch. Lond. Jour. Bot. 5: pl. 21–22, 1846.

Distribution: Known only from the Dept. of Antioquia, Colombia.

COLOMBIA: Without locality: *Mutis* 2473 (US); Antioquia: *Triana* s. no. (F, photo of type of *G. antioquiensis*); *Kalbreyer* s. no. F, G, photo, K); 1000 m. alt., *Lehman* 4087 (K, US), 4271 (F, US); Rio Negro and Medellin, *Jervise* s. no. (K); *Purdie* s. no. (K); *Triana* s. no. (F, photo, K, NY, P); Rio Negro, 2100 m. alt., *W. A. Archer* 305 (US); Santuario, *Daniel* 466 (NY, US); Medellin, *Toro* 710 (NY).

This species is readily distinguished from *G. obovata* on the following characters: its obovate-oblong and usually larger leaves, with more widely spaced and more prominently disposed secondary veins, and its much larger flowers. Although information obtained from labels is scarce, *G. antioquiensis* seems to be a smaller tree than *G. obovata*, reaching 10 m. in height. Its leaves are thicker and preserve their lustre in drying. Almost every sheet of *G. obovata* shows the leaves drying a dull yellow-brown or black. Further confirmatory evidence of the separability of the species is in its limited distribution in the Dept. of Antioquia, Colombia. Like *G. obovata*, it is restricted to high altitudes.

According to Purdie's field label the local name of the species is *Counso*; this, however, may be a misspelling for *Caunce*, annotated by Archer on his respective collection. The wood of *G. antioquiensis* is extremely durable, being used for axles and cogs.

## 2. GODOYA OBOVATA R. and P. Fl. Per. Prodr. 1: 58. 1794.

Trees up to 25 m. high; lenticels scattered; leaf-scars compressed-rotund or inversely triangular, 2.5–3.5 mm. long, 2–4.5 mm. wide; leaves thin-coriaceous, drying a dull lustrous brown or black above, obovate, 6.5–13 cm. long, 3–6.5 cm. wide, triangular or obtuse at apex, cuneate at base, the margin serrate (except 2–3 cm. from base), the teeth minute, 3–7 mm. apart, the costa subprominent above, plane beneath, 1.5–2 mm. wide at base, slender and evanescent at apex, the secondary veins 3–10 mm. apart, parallel-ascending, spreading from costa at 65°–70° angle, simple or infrequently bifurcating at middle or near margin, plane above and below;

stipulates fugacious; flower buds glandular-shiny, up to 2.5 cm. long, 1.1 cm. wide; inflorescence racemiform, the rachis terminal or axillary, up to 20 cm. long, the bracts (on immature rachises) whorled, imbricate, thin-coriaceous, striate, oblong-rectangular, up to 2 cm. long, obtuse and often retuse at apex, the subannular scars up to 3 cm. apart; the pedicels lignose, terete, 0.5–2 cm. long, 0.2–0.3 cm. wide, the articulation stalks 0.4–0.8 cm. long; sepals rectangular to oblong, 0.6–1.5 cm. long, 0.3–0.5 cm. wide, widely triangular or obtuse at apex, often retuse or split to middle,



FIG. 1. *GODOYA* R. and P.: *G. obovata* R. and P.: a—bud ( $\times 1$ ); b—sepal, ventral view, showing the inflated and gland-like cilia at the base ( $\times 1$ ); c—flower ( $\times 1$ ); longitudinal section through flower, showing half of the stamens in position ( $\times 2$ ); d—stamen dorsal view ( $\times 4$ ); e—apical portion of anther, showing the dehiscence pores ( $\times 8$ ). (a, drawn from Ruiz and Pavon 1634; b–f, drawn from Poeppig 1286.)

*G. antioquiensis* Planch.: g—fruit, perhaps immature ( $\times 1$ ); h—seed ( $\times 5$ ). (Drawn from Toro 710.)

obtuse at base, the margin entire; petals bright-yellow, unequal, obovate or elliptic, 20–30 mm. long, 17–20 mm. wide, round-obtuse and retuse at apex, constricted below middle or scarcely tapering, the veins flabellate, often distinct; anthers smooth, often slightly inflated, often seemingly 2-lobes, linear or narrow-elliptic, rotund-obtuse at apex, vaguely bilobed at base, the filaments 0.1–0.2 mm. long, almost as wide as base of anther; ovaries coriaceous, black or brown, smooth or striate, linear-fusiform, 15–20 mm. long, 1.5–2 mm. wide at base, 2.5–2.8 mm. wide at apex, the stigmas usually distinct, the ovules oblong, about 0.4 mm. long, 0.25 mm. wide, the terminal wing about 2 mm. long; fruit not seen (Fig. 1, a–f).

Type locality: Peru.

Distribution: Peru and Bolivia.

PERU: *Barbey* (?) s. no. (K); *Lambert* s. no. (K); *Ruiz* s. no. (K); *Ruiz and Pavon* 13164 (F); *Pinto Bamba* (?), *Pearce* s. no. (K); *Cuchero* (?), *Poeppig* 1286 (F, G, P); Lima: *Ruiz and Pavon* s. no. (K, type collection ?); Huánuco: *Chincao, Ruiz and Pavon* 95 (K); *Sawada* 92 (F). BOLIVIA: La Paz: *Mapiri Basin, Parannani*, 1000 m. alt., *Buchtien* 1774 (NY, US).

The specimen cited above as having been probably collected by *Barbey* has larger leaves and somewhat wider-spaced secondary veins; the shape of the lamina is much like that of the leaf-blade of *G. antioquiensis*. In other respects, however, it matches the other specimens of *G. obovata*. Anthers dissected from flowers of *Buchtien* 1774 and *Sawada* 92 were found to be inflated. The limited number of flowers available for dissection made a thorough study of this interesting condition impossible.

## 2. RHYTIDANTHERA van Tieghem, Ann. Sci. Nat. VIII. 19: 43. 1904.

*Godoya* subgen. *Rhytidanthera* Planch. Lond. Jour. Bot. 5: 599. 1846.

Shrubs or trees; lenticels minute; leaves pinnate, the leaflets 8–10, borne on short petioles, unequal, odd-pinnate, the lateral leaflets paired, the margin serrate or doubly serrate, the teeth minute, the costa prominent above and below, the secondary veins well-spaced, oblique and parallel-ascending; stipules deciduous; inflorescence terminal, patent-paniculate, the flowers solitary or fasciculate, the bracts amplexicaul, subcoriaceous, strigose, concave, erose-marginate, with minute appendages adaxially and proximally, the pedicels stout, coriaceous, articulate at base; flower-buds elliptic; sepals 4–5, unequal, fugacious, subcoriaceous, concave; petals 5, white, unequal or subequal, thin-carnose, longer than sepals, the veins parallel-ascending, flabellate toward margin; stamens 20–50, encircling pistil, deciduous at anthesis, the anthers bright-yellow, incurved, linear, dehiscing by two terminal pores, attached basally, the filaments shorter than anthers; pistil secund at anthesis, pentacarpellate, one-celled, short-stipitate, the stigmas 5, sessile, radiating, spongy, the style short, subfalcate, the ovary narrowly fusiform, the ovules very numerous, imbricate and in several rows on 5 intrusive T-shaped parietal placentae; fruit capsular, dehiscing septicidally, the margins of carpels separating from placentae, the latter filamentous, rough with persistent funiculi, the seeds imbricate, oblong, conspicuously and unequally winged at the ends, the wing exceeding body of seed in length (Fig. 2).

Type species: *Godoya splendida* Planch.

Van Tieghem, although devoting little discussion to generic relationships in the Luxemburgieae, segregated this remarkable pinnate-leaved group of plants, localized in Colombia, as a distinct genus. This leaf condition is unique not only in the tribe Luxemburgieae but also in the entire family Ochnaceae.

Previous workers have linked this group to *Godoya* but have failed to realize its closer relationship to *Cespedezia* with which it agrees in the fol-



lowing important characters: numerous stamens, linear anthers with elongate slender filaments, paniculate and strictly terminal inflorescence, and imbricate, appressed, amplexicaul, and frequently persistent bracts. Its relationship with *Godoya*, on the other hand, is especially manifest in the general structure of the sepals. Little attention has been directed to flower-color which is known to be white in two of the three species. This color has not been reported in the species of *Godoya*, *Cespedezia*, and *Krukoviella*.

## KEY TO THE SPECIES

- Petals oblong-rotund; stamens about 50; capsules 3.5-5.5+ cm. long. . . . . 1. *R. sulcata*.  
 Petals obovate-spatulate; stamens 18-20; capsules 1.5-1.8 cm. long  
   Leaf-blades 2-5 cm. wide; flowers solitary in a terminal raceme; petals 1.5-2 cm. long. . . . .  
     . . . . . 2. *R. splendida*.  
   Leaf-blades 5-6 cm. wide; flowers both solitary and fasciculate in a terminal raceme; petals  
     2.5-3.5 cm. wide. . . . . 3. *R. magnifica*.

I. RHYTIDANTHERA SULCATA van Tieghem, Ann. Sci. Nat. VIII. 19: 44. 1904.

*Rhytidanthera fragrans* van Tieghem, Ann. Sci. Nat. VIII. 19: 44. 1904.

Shrubs 2-3 m. high; stems erect, simple, branching at apex, about 4 cm. (+?) in diameter; leaves well spaced along twigs, somewhat pendent, the petioles 20-30 cm. long, the leaflets 8, lateral, one terminal and free (or the uppermost pair fused for a short distance at base), those paired alternate or subopposite, 4.5-6.5 cm. apart, obovate-oblong to oblong, 12-14 cm. long, 5.5± cm. wide, the lowest pair shorter, 6.8-10.5 cm. long, 4-5.5 cm. wide, subobtusate at apex, often splitting along costa, flat-obtusate or vaguely cordate at base, the costa prominent above, very prominent beneath, the secondary veins 17-20, 4-7 mm. apart, immersed above, prominent beneath, the margin doubly serrate, the teeth 4-9.5 mm. apart; stipules deciduous; inflorescence extending (here) a half meter above uppermost leaves, about as wide as long, the branches almost horizontal, the flowers solitary at apices of branches, fasciculate toward base, the bracts appressed, imbricate, shield-shaped, entire or retuse (often split) at apex, ovate-triangular, 2-8 mm. long, a little longer than wide, often enclosing small buds, the pedicels about 1.5 cm. long, 0.15-0.2 cm. wide toward base, 0.3-0.4 cm. wide and clavate at apex; sepals unequal, imbricate, glandular-lustrous, strigose on outside, concave, oblong-rotund or oblong, 8-11 mm. long, 5-8 mm. wide, splitting freely at apex; petals white, oblong-rotund, 3-3.5 cm. long, about 2 cm. wide; stamens about 50, the anthers smooth (here in bud), up to 11.5 mm. long, 0.8 mm. wide, the filaments about 2.5 mm. long; pistil crassate, narrow-fusiform, up to 13 mm. long, narrowing toward apex, the style indeterminate, the stigmas 5, sessile, radial; capsules minute-rugose, narrowly subfalcate, 3.5-5.5 cm. long, the median vein of each carpel subplane and evanescent, the seeds (here immature)

oblong, about 0.7 mm. long, the wing about  $3\times$  length of body of seed (Fig. 2 h, j).

Type locality: Dept. Santander, Colombia.

Distribution: Known only from the eastern cordillera of Colombia.

COLOMBIA: Santander: Mesa de los Santos, 1500 m. alt., Killip and Smith 15217 (G, F, NY); Santander: Socorro: Linden 765 (F, photo of type of *R. sulcata*); Ocaña: Schlim 1144 (K, type collection of *R. fragrans*).



FIG. 2. RHYTIDANTHERA van Tieghem.—*R. magnifica* (Gleason) Dwyer: a—bud ( $\times 1.5$ ); b—flower ( $\times 1.5$ ); c—stamen, dorsal view ( $\times 4$ ); d—apical portion of anther ( $\times 8$ ); e—leaf ( $\times 0.25$ ); f, g—portions of leaflet edge showing venation and the two types of marginal teeth ( $\times 2$ ). (Drawn from Lawrence 599, TYPE.)

*R. sulcata* van Tieghem: h—capsule, after dehiscence, ( $\times 1$ ); j—seed ( $\times 5$ ). (Drawn from Killip and Smith 15217.)

Van Tieghem's "descriptions" of *R. sulcata* and *R. fragrans* are simply notations of the differences between his species and the type species of the genus, *R. splendida*. He makes no attempt to compare or contrast his new species with the type species. From an examination of the type collection

of *R. fragrans* deposited in Kew Gardens and the photo of the type of *R. sulcata* in the Field Museum I have been unable to find characters worthy of separating the two collections as species.

2. *RHYTIDANTHERA SPLENDIDA* (Planch.) van Tieghem, Ann. Sci. Nat. VIII. 19: 44. 1904.

*Godoya splendida* Planch. Lond. Jour. Bot. 5: 599. 1846.

Trees; petiole of leaves up to 45 cm. long, the leaflets 9, sessile, those lateral paired, 5.3–7.3 cm. apart, oblong, 13–18.5 cm. long, 5–6 cm. wide, triangular-acute at apex, obtuse at base (flat-obtuse in the 4 basal leaflets) or the three terminal leaflets fused at the base in a cuneate fashion with the apex of the petiole, the costa prominent above and below, the secondary veins 20–25, somewhat prominent above and below, 6–10 mm. apart, slightly arcuate-ascending, the marginal teeth minute, 5–10 mm. apart, often with a minute median tooth; stipules deciduous; inflorescence paniculate, the rachis exceeding the leaves in length, terete at base, about 7 mm. wide, becoming angular and somewhat contorted toward apex, bearing thin, transverse, and circular bract scars, the basal branches elongate, up to 25 cm. long, the upper branches shorter, the pedicels stout, lignose, 8–9 mm. long, clavate at apex, 1–1.5 mm. wide at base in flower, 2 mm. wide at apex, about 2 mm. wide at base in fruit, 3 mm. wide at apex, articulate on a thick terete oblique projection of the rachis; flower buds not seen; sepals subcoriaceous, strigose, unequal, the outer obovate, about 5 mm. long, 4 mm. wide, the inner oblong, longer, up to 1.5 mm. wide, subacute at apex; petals unequal, obovate-spatulate, 2.5–3.5 cm. long, 1.4–1.6 cm. wide, round-obtuse and slightly inequilateral at apex, spatulate or narrow-cuneate at base; stamens 18–20, the anthers subequal, incurved, transversely rugose, exceeding filaments in length, about 0.7 mm. wide, the filaments about 3 mm. long; pistil secund at anthesis, black, smooth, the ovary linear-fusiform, about 10 mm. long at maturity, constricted at apex into a short subfalcate style about 4 mm. long; capsule (here immature) 1.5–1.8 cm. long, acute, the seeds obovate or oblong, about 0.7 mm. long, the terminal wing wider than seed, about 0.3 mm. long.

Type locality: Dept. of Magdalena, La Cruz, Mompos, Colombia.

Illustration: Planch. Lond. Jour. Bot. 5: pls. 19–20. 1846.

Distribution: Known only from the type locality.

COLOMBIA: Magdalena: Mompos, La Cruz, *Purdie* s. no. (K, type collection of *G. splendida*).

3. *Rhytidanthera magnifica* (Gleason) Dwyer, comb. nov.

*Godoya magnifica* Gleason, Phytologia 1: 27. 1933.

Trees 15–20 m. high; petioles of leaves 15–17 cm. long, the leaflets 9–10, minutely rugose, sessile, paired, the pairs 3–3.5 cm. apart, narrowly or



widely lanceolate, 6–17 cm. long, 2–5.3 cm. wide (the basal pair obviously opposite, 6.5–7 cm. long, 2–3 cm. wide), acute at apex, inequilateral and flat-obtuse at base (or the basal lamina of the 2 terminal leaflets often fusing cuneately with the apex of petiole), the costa prominent above, sub-prominent below, evanescent toward apex, the secondary veins slender, 20+, plane above, prominent beneath, arcuate-ascending, 4–8 mm. apart, the margin coarsely and doubly dentate, the teeth incurved, minute, 0.4–1.3 cm. apart, the intermediate teeth smaller; inflorescence terminal, patent, paniculate, the flowers solitary, 15–20 per branch, the pedicels 1–1.2 cm. long, 0.1–0.15 cm. wide at base, 0.3–0.35 cm. wide above; flower-buds up to 1.5 cm. long, about 1 cm. wide; sepals 4–6, unequal, concave, often dorsally carinate, the outermost the smallest, ovate-rotund, 0.75–1.4 cm. long, 0.7–0.9 cm. wide, the inner larger, oblong, 1.1–1.5 cm. long, 1–1.1 cm. wide, obtuse obtuse and often deeply fissured at apex, the margin entire; petals white, unequal, oblong or obovate-oblong, 1.6–2.1 cm. long, 0.8–0.95 cm. wide, rotund and often inequilateral at apex, spatulate or obtuse at base; stamens 40–50, the anthers often transverse-rugose, 0.95–1.1 cm. long, 0.75 mm. wide at base, the filaments about 0.3 cm. long, 0.03 cm. wide; ovary fusiform, about equal to stamens in length, tapering gradually into a crassage style about 0.2 cm. long, the stigmas 5, sessile, radical; fruit not seen.

Type locality: El Umbo Region, Dept. Boyacá, 1200–1500 m. alt., Colombia.

Distribution: Known only from the type locality.

COLOMBIA: Boyacá: El Umbo Region, *Lawrence 599* (G, F, NY, type collections of *C. magnifica*).

*R. magnifica* is readily distinguished from the two other species of the genus by its narrower leaflets which taper toward the base, its constantly non-fasciculate flowers, and longer petals. The number of the stamens and the length of the pedicels point to it being more closely related to *R. sulcata*. Although both of these species have white flowers, the importance of this character as indicating close relationship between the two species is uncertain, since there is no record of the color of the petals of *R. splendida*. Fruiting material of *R. magnifica* is desirable for comparative study. "Asuseno" is the native name given to the durable wood of this species. According to the collector it is used for making gears for sugar mills.

### 3. *CESPEDEZIA* Goudot, Ann. Sci. Nat. III, 2: 370. 1844.

*Godoya* R. and P. Fl. Per. Prodr. 1: 58. 1794. In Part.

*Fourneiria* van Tieghem, Ann. Sci. Nat. VIII. 19: 58. 1904.

Large trees; branches whorled and clustered at apices of trunk; petioles of leaves short; leaf-blades simple, glabrous, the costa prominent above and below, the secondary veins arcuate-ascending, the margin sinuate, the

marginal teeth minute; stipules persistent, densely imbricate, and appressed at base of crowded leaf-blades, entire, bearing minute appendages on the basal and adaxial margin; inflorescence patent, terminal, paniculate, the flowers in fascicles, the basal branches arcuate-ascending, the pedicels short-articulate at base, the bracts deciduous, bearing minute appendages on the basal and adaxial margin; flower buds obovate or oblong; sepals 5, subequal or obviously unequal, imbricate at base and united into a short cup, coriaceous, dorsally marcescent and carinate, ventrally smooth, bearing minute appendages on the basal and inner margin; petals 5, yellow, equal, the veins flabellate; stamens 50-80, in several rows encircling the pistil, the anthers soon deciduous, 4-celled, opening by two oblique and terminal pores, the filaments slender, often longer than anthers; pistil stipitate, second, the ovary 1-celled, 5-carpellate, the ovules borne in several series on intrusive T-shaped placentae, the style short, the stigmas 5, spongy, radial; fruit capsular, dehiscing septicidally, the carpels coriaceous, the placentae at dehiscence separating from the margins of carpels, the seeds imbricate, long-winged, the wings subequal, scarcely wider than the body of the seed (Fig. 3).

Type species: *Godoya spathulata* R. and P. Fl. Per. Prodr. 1: 58. 1794.

#### KEY TO THE SPECIES

Sepals entire at apex; petals 1-2 cm. long

Leaf-blades coriaceous

Lateral veins on underside of leaf-blade prominent and ridge-like. . . . . 1. *C. macrophylla*.

Lateral veins plane or prominulous on underside of leaf-blade

Leaf-blades flat obtuse at apex; petioles plane above at distal end. . . . . 2. *C. excelsa*.

Leaf-blades acuminate or obtuse at apex; petioles terete at distal end

Leaf-blades narrow-obovate; secondary veins in middle of the blades 1.5-2.5 cm. apart; pedicels at anthesis 0.7-1.2 cm. long; petals 1-1.5 cm. long. . . . . 3. *C. repanda*.

Leaf-blades oblanceolate or spatulate; secondary veins in middle of blade 0.7-1.5 cm. apart (only in larger leaf-blades up to 2 cm. apart); pedicels at anthesis 1.3-2 cm. long; petals 1.4-2 cm. long. . . . . 4. *C. spathulata*.

Leaf-blades membranaceous. . . . . 5. *C. scandens*.

Sepals retuse at apex; petals 2-2.5 cm. long. . . . . 6. *C. braziliiana*.

#### 1. CESPEDEZIA MACROPHYLLA Seem. Bot. Voy. Herald 97. 1853.

Large trees up to 15 m. high, with aerial roots and buttresses; leaf-scars compressed-rotund, fossulate, up to 1.3 mm. wide, about 1 mm. long; petioles about 1 cm. long, plane above; leaf-blades coriaceous (or subpapyro-membranaceous), obovate or obovate-elliptic, 45-75 cm. long, 18-25 cm. wide, obtuse, often retuse above, cuneate at base, the costa prominent and carinate above, prominent beneath, up to 0.4 cm. wide, the secondary veins 1-2 cm. apart in middle, prominent above and below, ascending from costa at a 50°-60° angle, the tertiary veins subimmersed above and below, the margin widely sinuate, the cilia minute, falcate, up to 3.5 cm. apart; stipules thin-coriaceous, dense, imbricate, appressed, linear-rectangular, up to 7 cm. long, up to 1.3 cm. wide, obtuse above, tending

to split, the basal and adaxial appendages up to 1 cm. long; inflorescence paniculate, the flowers fasciculate, the rachis exceeding uppermost leaves, the pedicels angular, 1.3–1.5 cm. long, the flower-buds elliptic, up to 2 cm. long; sepals subequal, nonimbricate at anthesis, coriaceous, dome-shaped, about as long as broad, up to 2.3 cm. long, the margin with irregular and glandular teeth up to 0.1 cm. long; petals yellow, obovate,

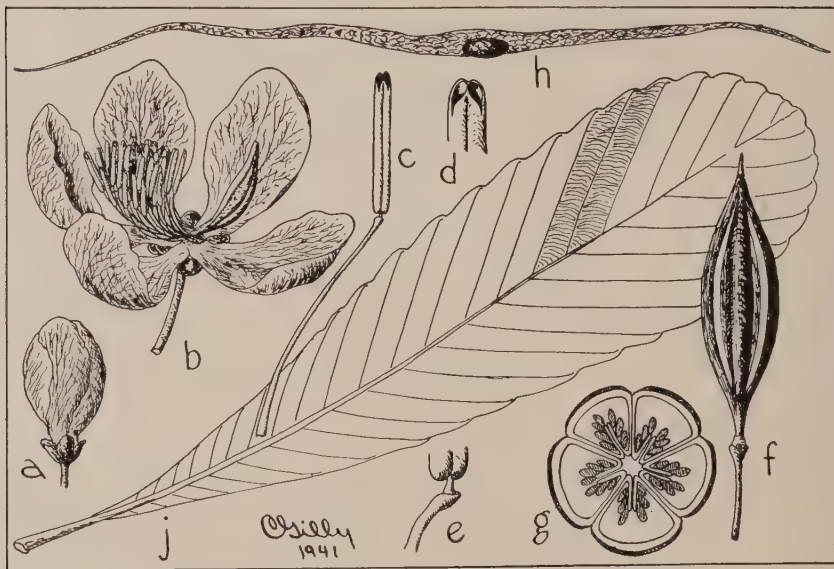


FIG. 3. *CESPEDEZIA* Goudot.—*C. spatulata* (R. and P.) Planch.: a—bud ( $\times 1.5$ ); b—flower ( $\times 1.5$ ); c—stamen ( $\times 4$ ); d—apical portion of anther ( $\times 8$ ); e—basal portion of anther, showing detail of filament attachment ( $\times 8$ ). (Drawn from *Ducke 12241*.)

*C. repanda* (Kunth) van Tieghem: f—capsule ( $\times 1$ ); g—diagrammatic cross-section of pistil, showing placentation; h—seed ( $\times 5$ ); j—leaf, the secondary venation shown only in part ( $\times 0.12$ ). (Drawn from *Bonpland* s. no. TYPE.)

up to 1.8 cm. long, 1.1 cm. wide, tapering cuneately or obtusely toward base; stamens  $80 \pm$ , the anthers about 0.95 cm. long, 0.5 mm. wide, the filaments up to 1.2 cm. long, scarcely swollen above; pistil usually striate, narrow-oblongate, stipitate, up to 0.7 cm. long, the ovules numerous, about 0.3 mm. long, about 0.1 mm. wide; fruit (here immature) linear-falcate, up to 6.5 cm. long, 0.7 cm. wide, the seeds angular, 0.1–0.13 cm. long, each wing about 0.8 cm. long.

Type locality: Bay of Utria, Panama.

Distribution: Limited to Nicaragua, Costa Rica, Panama, Canal Zone, and Colombia.

NICARAGUA: Braggman's Bluff, *Englesing 274* (F). COSTA RICA: Suerre de Santa Clara, 300 m. alt., *J. D. Smith 6460* (US). PANAMA: Gatum, *Hayes* s. no. (K); Penome, *Williams 424* (NY, US); Obalida, San Blas, *Pittier 4340* (F, G, NY, US); Changuinola Valley, *Cooper and Slatter 121*



(F, US); Bay of Utria, *Seeman* s. no. (G, K, type collection of *C. macrophylla*). CANAL ZONE: Barro Colorado Island: *Kenoyer* 665 (NY); *Shattuck* 791 (F); *Wilson* 155 (F); *Woodworth* and *Vestal* 411 (F). COLOMBIA: El Chocó: Rio Condoto and Rio San Juan, *Killip* 35102 (US); Narino: Gorgona Island, *Killip* and *Garcia* 33100 (US).

Although *C. macrophylla* shows much diversity in leaf-shape, it is readily recognized by the secondary veins of the leaf-blade which are prominent beneath. The papyro-membranaceous leaf-blades of *J. D. Smith* 6460 are probably immature. As in *C. spathulata* (R. and P.) Planch. the leaves vary from being subacute to flat-obtuse at the apices.

2. *CESPEDEZIA EXCELSA* Rusby, Mem. Torrey Club 6: 17. 1896.

Trees up to 20 m. high; petioles stout, plane (or concave) at distal end above, up to 0.8 cm. wide; leaf-blades thin-coriaceous, obovate-spatulate, 40–100 cm. long, 12–18 cm. wide, flat-obtuse at apex, cuneate at base, the costa prominent and ridge-like above, tapering toward apex, scarcely prominent below, up to 0.5 cm. wide in middle, the secondary veins prominent and ridge-like above, sub-plane beneath, spreading from costa at 50°–65° angle, 1–2 cm. apart in middle, the margin sinuate, entire toward proximal end, the teeth minute, 0.5 mm. long, 1.5–3 cm. apart, located at base of sinuate lobe (rarely in middle); stipules thin-coriaceous, narrowly rectangular to square, up to 6 cm. long, up to 1.5 cm. wide at base, obtuse above and below, the margin tending to split, often with deep sinus at apex; inflorescence patent-paniculate, the flowers mostly 3 per fascicle, the rachis smooth below, becoming contorted above, up to 1.5 cm. wide at base, the basal branches arcuate-ascending, up to 25 cm. long, 6–7 cm. apart, the uppermost branches shorter, the first fascicle on uppermost branch 4–8 cm. from base, the pedicels lignose, 0.9–1.3 cm. long, sharply ascending, the flower buds obovate, up to 2.2 cm. long, 0.9 cm. wide; sepals subequal, thick-coriaceous (especially outer sepals), imbricate at base, ovate-rotund, about one-seventh length of petals, up to 3.5 mm. long, obtuse-rotund at apex, obtuse to subauriculate at base, the outer surface vague-marcescent, the margin entire or with minute blunt ascending teeth; petals yellow, obovate, up to 18 mm. long, about 8 mm. wide, erose-marginate at apex, the veins frequently indistinct; anthers linear-falcate, up to 6 mm. long, the filaments unequal, 0.5–0.95 cm. long, narrow-clavate at apex; ovaries linear-elliptic, up to 12 mm. long, the stigmas distinct; capsule minutely glandular-rugose, linear-fusiform before dehiscence, falcate or suberect, up to 3 cm. long (immature here), 0.4 cm. wide, when dehiscent up to 6 cm. long, the carpels black except on margins, silver-gray within, the seeds linear, 2 mm. long, 0.25 mm. wide, the wings about 5.5 mm. long.

Type locality: Between Tipuani and Guaiana, La Paz, Bolivia.

Distribution: Known only from several collections in Bolivia.

BOLIVIA: La Paz: Tipuani-Guaiana, *Bang* 1723 (NY, type collection of *C. excelsa*, with distributional numbers 1652 or 1658 a (G, F, US); Mapiri, *Buchtien* 1724 (G, NY, US), *Buchtien* 2045 (NY, US); Larecaja, Copacabana, *Krukoff* 11232 (NY).

3. *CESPEDEZIA REPANDA* (HBK) van Tieghem, Ann. Sci. Nat. VIII. 19: 50. 1904.

*Godoya repanda* H. B. K. Nov. Gen. et Sp. 7: 277. 1825.

Trees up to 30 m. high; petioles 3-4 cm. long, 0.5 cm. wide distally, the costa of blade carinate proximally, the leaf-blades narrow-obovate, 35-65 cm. long, 8-15 cm. wide, obtuse at apex, cuneate at base, the margin subserrate toward base, widely undulate above, the marginal teeth about 0.5 mm. long, 2-4.5 cm. apart, often with smaller cilia along the margin, the costa carinate above, subplane and conspicuous beneath, the secondary veins prominent above, subplane beneath, 1.5-2.5 cm. apart in middle of blade, leaving costa at 45°-50° angle; stipules striate, oblong-rectangular or obovate-oblong, 1.7-2 cm. long, 1.2 cm. wide; inflorescence patent-paniculate, the flowers fasciculate along upper two-thirds of branches, the rachis elongate, exceeding uppermost leafblades, up to 1.8 cm. wide at base, subterete, the basal branches elongate, arcuate-ascending, the pedicels lignose, slender, 0.7-1.2 cm. long, about 0.8 mm. wide in middle; flower buds narrow-obovate, up to 1.2 cm. long; sepals subequal, marcescent outside, reflexed at anthesis, ovate or compressed-rotund, 2-3 mm. long, 2-2.5 mm. wide, obtuse at apex, the margin entire or with small obtuse teeth, the latter usually crowded at base; petals bright yellow, subcarnose, narrowly obovate, 10-15 mm. long, 0.65-0.75 cm. wide, obtuse at apex, tapering below; stamens 55 or more, the anthers linear-falcate, about 4 mm. long, the filaments about same length; pistil linear-elliptic, about 10 mm. long, 16 mm. wide, the style short and rostrate; capsule (indehiscent here) linear, the seeds subplane, oblong, about 1 mm. long, 0.3 mm. wide, each wing linear-subulate, 2.8-5.5 mm. long (Fig. 3, *f-h, j*).

Type locality: Mariquita, Tolima, Colombia.

Distribution: Distributed throughout Colombia and Peru.

COLOMBIA: Without locality, *Mutis* 4456 (US); Boyacá: El Humba, *Lawrance* 618 (F, US); Tolima: Mariquata, *Bonpland* s. no. (P, type of *C. repanda*); Triana s. no. (K, NY); El Chocó: Timbio, *Woronow* 6990 (F). PERU: Without locality, *Poeppig* s. no. (P).

Goudot (Ann. Sci. Nat. III. 370. 1844) cites *Godoya repanda* HBK as a synonym of his species *C. Bonplandi*, apparently without having examined the type material of this species. A study of the type collections indicates that *C. repanda* is valid while *C. Bonplandi* is a synonym of Ruiz and Pavon's *C. spathulata*. Comparing equally sized leaf blades of both species one finds that the secondary veins of *C. repanda* are obviously more widely spaced than in *C. spathulata*. Other differentiating characters are the shorter petals and pedicels of *C. repanda*.

4. *CESPEDEZIA SPATHULATA* (R. and P.) Planch. Lond. Jour. Bot. **5**: 647. 1846.

*Godoya spathulata* R. and P. Fl. Per. Prodr. **1**: 58. 1794.

*Cespedezia Bonplandi* Goudot, Ann. Sci. Nat. III. 370. 1844.

*Cespedezia Sprucei* van Tieghem, Ann. Sci. Nat. VIII. **19**: 50. 1850.

*Cespedezia amazonica* Huber, Bot. Mus. Goeldi **7**: 302. 1913.

Large trees up to 25 m. high; petioles of leaves 1–3 cm. long, plane above; leaf blades coriaceous, oblanceolate-spatulate, up to 80 cm. long, up to 26 cm. wide, tapering acutely above, subobtusate to distinctly obtuse at apex, cuneate at base, the costa prominent and ridge-like above, scarcely prominent or distinctly so beneath, 0.18–0.4 cm. wide in middle, the secondary veins prominent above, subplane beneath, 0.7–2 cm. apart, somewhat arcuate-ascending at 50°–65° angle, the tertiary veins distinctly or vaguely immersed above, immersed beneath; stipules thin-coriaceous, short-rectangular or narrow-elliptic, 1–3.5 cm. long, 0.9–1.7 cm. wide, the smaller often as broad as long, retuse or tending to split at apex; inflorescence terminal, paniculate, the rachis smooth, usually contorted toward apex, up to 60 cm. long, the basal branches up to 40 cm. long, the flowers mostly 3 per fascicle, the pedicels usually slender, 1.3–2 cm. long, short articulate at base, the flower buds oblong, 1.2–1.5 cm. long; sepals subequal, thick-coriaceous, imbricate, dorsally marcescent, fused into a small cup at base, ovate-rotund, compressed-rotund to almost square (rarely broader than long), 1.7–3 mm. long, obtuse and entire at apex, subauriculate at base, the margin with minute obtuse teeth; petals carnose, obovate or narrow-obovate-oblong, 14–20 mm. long, up to 9 mm. wide, tapering obtusely at base; stamens up to 100, the filaments up to 8 mm. long, usually twice length of anthers, the anthers 3.5–5.5 mm. long; pistil linear-oblong, about 10 mm. long; fruits (before dehiscence) linear-subulate, smooth, drying purple-brown, linear, often falcate, acute, up to 7 cm. long, up to 0.4 cm. wide, the dehiscent fruit 4.5–7.5 cm. long, the seeds oblong, about 0.1 cm. long, 0.05 cm. wide, the wings transparent, 0.85–1.5 cm. long (Fig. 3, a–e).

Type locality: Peru.

Distribution: British Guiana, Colombia, Brazil, Peru, and Ecuador.

BRITISH GUIANA: Demarara, Yampari Creek, Georgetown, *Davis* 930 (K); Demarara, *Hohenkerk* 814 (K); Demarara River *Jenmann* 2444 (K, NY, US); 4168 (K, NY); Upper Kamuni, Demarara River, *Anderson* 153 (K); COLUMBIA: Vaupes: De Cupati, Rio Yapura, *Ducke* 12241 (P, US, type collection of *C. amazonica*). PERU: Without locality, *Fox* 120 (K); Huánuco: Chincnao, *Ruiz* and *Pavon* s. no. (K, type collection of *Godoya spathulata* ?); Mat. Campana, Tarapoto, *Spruce* 4831 (F, G, K, NY, type collection of *C. Sprucei*); Amazonas: Rio Santiago, *Tessmann* 4178 (NY); San Martin: Zepalacio, *Klug* 3428 (F, G, NY, US); Lamas, *Llewellyn Williams* 6460 (F, G, US); Loreto: Mishuyacu, *Klug* 124 (F, NY, US); Junin: La Merced, *Killip* and *Smith* 23888 (NY). ECUADOR: Quilaquiza, *von Hagen* 290, 291, 293 (NY); Esmeraldas: San Lorenzo, *Little* 6357 (US). BRAZIL: Amazonas: São Paulo de Olivacença, *Ducke* 20707 (F); Matto Grosso: Serra do Chapadá, *Riedel* 1194 (?) (NY).



According to Little's (6357) label this species is known as "Sajo" and "Pacora" in the vicinity of San Lorenzo, Esmeraldas, Ecuador.

5. **Cespedezia scandens** (van Tieghem) Dwyer, comb. nov.

*Fourniera scandens* van Tieghem, Ann. Sci. Nat. VIII. 19: 58. 1904.

Vine?; petioles of leaves about 1.5 cm. long; leaf-blades membranaceous, oblanceolate, 30–60 cm. long, 9–16 cm. wide, acute at apex, often acuminate, cuneate at base, the costa thin, ridge-like above, widening and often striate proximally, the secondary veins prominent above, subplane beneath, 1–1.2 cm. apart, ascending at a 60°–65° angle from costa, the margin widely undulate, the lobes 0.7–2 cm. long, the teeth wanting or 1–3 on margins of lobes, ascending, uncinata, up to 0.05 cm. long; stipules linear-lanceolate, up to 4.5 cm. long, subauriculate at base, the margin entire or often splitting; inflorescence paniculate, terminal (?), the rachis angular, finely striate, the fascicles of flowers alternate, paired, each pair 1–4 cm. apart below the middle of the branch, the pedicels stout, lignose, up to 1.3 cm. long at anthesis, deciduous, leaving stout and circular scars 1–1.8 mm. wide, the bracts of pedicels ovate-lanceolate, up to 0.25 cm. long, the marginal cilia few and short; sepals thick-coriaceous, unequal, imbricate at base, ovate-oblong, about one-fifth the length of petals, dorsally marcescent, the veins prominent on outside, obtuse to subacute at apex, obtuse to subauriculate at base; petals subequal, subcarinose, obovate, up to 20 mm. long, the veins well spaced, flabellate, branching above middle; stamens 70+, the filaments narrow-ligulate at apex, 10.5–12 long, about 0.25 mm. wide at apex, the anthers up to 6 mm. long, about 0.5 mm. wide; capsule (immature here) fusiform-falcate, 1.4 cm. long, 0.4 cm. wide.

Type locality: Chontales, 600 m. alt., Nicaragua.

Distribution: Known only from the type locality.

NICARAGUA: Chontales: *Levy 467* (F, photo of type; K type collection of *F. scandens*).

The single collection of this species is noted by van Tieghem in his original description as a vine. Since there is no indication of the habit of the plant on the label of the Kew material or on the photograph of the type, we have no way in which we might check on the accuracy of his statement. It is noteworthy that the five other species of the genus are trees of considerable height. Whether the membranaceous leaf-blades of this collection are mature is important as membranaceous leaf-blades are not found in any other species of *Cespedezia*. Since the material cited above has a piece of the obviously mature inflorescence, we may infer that these are mature.

*C. scandens* is related to *C. macrophylla* Seem., the only other species collected in Nicaragua. The differences between the species are manifest

in the texture, size apex, and disposition of the secondary veins of the leaf-blades, and in the habits of the plants.

6. *CESPEDEZIA BRAZILIANA* van Tieghem. Ann. Sci. Nat. VIII. 19: 51: 1904.

Trees; petioles up to 1.5 cm. long or absent, plane or subconcave on upper surface; leaf-blades whorled, narrowly elliptic-lanceolate up to 70 cm. long, 13 cm. wide, subacute to acute at apex, narrow-cuneate at base, the costa prominent, striate, ridge-like above, the secondary veins prominent above, subplane below, arcuate-ascending, spreading from costa at a 50°-60° angle, 1-1.7 cm. apart in middle, the tertiary veins plane above, immersed beneath, the margin sinuate, the lobes 1-3 cm. apart, the marginal teeth ascending, falcate, about 0.1 cm. long; stipules thin-coriaceous, densely imbricate, linear-elliptic or narrow-rectangular, 2-2.5 cm. long, slender-striate on outside, obtuse at apex, often splitting at apex; inflorescence a patent terminal panicle, the rachis angular, smooth, up to 35 cm. long, the branches elongate, arcuate-ascending, those at base up to 20 cm. long, the flowers usually three per fascicle, the pedicels lignose, expanding distally at anthesis, 1.8-2 cm. long, about 0.1 cm. wide in middle, the articulation-stalks up to 0.6 cm. long, the flower buds obovate, up to 2.2 cm. long, up to 1.1 cm. wide; sepals unequal, imbricate at base, subcoriaceous or subscariosus, vaguely marcescent or smooth, carinate on outer surface, obcordate to rotund, 3-4, 5 mm. long, 2.5-3.5 mm. wide, often wider than long, retuse at apex, the sinus up to 1 mm. deep; petals subequal, obovate, 23-25 mm. long, 13-17 mm. wide, cuneate or tapering obtusely at base, obtuse and retuse at apex, the veins well-spaced, flabellate, branching freely toward apex; stamens  $70 \pm$ , the filaments slender, up to 13 mm. long, the anthers linear-falcate, up to 7 mm. long; capsule (immature here), linear-falcate, 18 mm. long.

Type locality: State of Santa Catherina, Brazil.

Distribution: Known from the States of Matto Grosso and Santa Catherina, Brazil.

BRAZIL: Matto Grosso: *Collennette* 123 (K); Santa Catherina: *Weddell* 3027 (P, type of *C. braziliiana*, F, frag.).

The sepals of *C. braziliiana* provide the strongest distinguishing characters. Unlike the other species of the genus these are frequently scariosus in texture, at least being obviously thinner than those of the other species of *Cespedezia*. The conspicuously retuse condition of the apex of its sepals and their obcordate shape stand in sharp contrast to the remainder of the genus.

## Supplementary Notes on the American Species of *Strychnos*—II

B. A. KRUKOFF AND J. MONACHINO  
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Extensive collections of *Strychnos*, largely from Brazil, Colombia, Surinam and Venezuela, recently became available to us. We have also been able to examine specimens deposited in the three European herbaria mentioned below. The collections examined extend our knowledge of certain species previously known to us from incomplete material or only from descriptions; extensions of ranges are noted for a considerable number of species; one species, *Strychnos Duckei*, is described as new, and another new species, *S. pachycarpa*, recently described by Ducke (1), is reviewed by us.

The species noted in this supplement are arranged in the same order, and the place of deposit of specimens is shown by the same abbreviations, as in our previous papers on *Strychnos* (2, 3). The following additional abbreviations are used:

G: Conservatoire et Jardin Botanique, Geneva

P: Museum d'Histoire Naturelle, Paris

R: Secção do Botanico do Museu Nacional, Rio de Janeiro

S: Naturhistoriska Riksmuseet, Stockholm

### 2. *STRYCHNOS RAMENTIFERA* Ducke.

BRAZIL: Para: Ducke 1658 (A, F, NY).

This collection of the species is the second known to us. Ducke notes on the label: "ad viam ferreani km. 18, silva non inundabili. Frutex robustissimus altissimi scandens."

In his recent paper under this species (1, p. 11) Ducke states: "Cipó robusto, frequente na mata da terra firme dos arredores de Belem do Para. Notavel pelos frutos que são tão volumosos como os de *Str. pachycarpa*, embora de estrutura diferente."

### 3. *STRYCHNOS ASPERULA* Sprague & Sandw.

BRAZIL: Territory of Acre: Basin of Rio Acre, Ule 9838 (G).

We now have examined the type collection of the species. In the previous paper our description was taken from the original description of it by Sprague and Sandwith. The following changes in the key to the species of *Strychnos* appear to be necessary (2, p. 262):

1. The sentence: "Anthers 1.75–2.75 mm. long and acuminate at base; corolla-tube glabrous and not papillose without, not pilose within" should read: "Anthers 1.75–2.75 mm. long and acuminate at base; corolla-tube



glabrous and not papillose without, not pilose within, corolla-lobes sparsely pilose within near sinuses."

2. In the sentence: "Filaments not distinct, anthers over 2 mm. long; corolla-tube about 1.5 cm. long or longer, corolla-lobes sparsely pilose within near sinuses"—the last part, namely "corolla-lobes sparsely pilose within near sinuses," should be deleted.

3. In the sentence: "Filaments distinct but short, anthers about 1.75 mm. long, glabrous; corolla-tube about 0.85 cm. long, corolla-lobes glabrous within"—the last part, namely "corolla-lobes glabrous within," should be deleted.

In the same paper (2, p. 266), in the description of the species, the sentence: "corolla-lobes about 2.5 mm. long, glabrous without, cinereous-papillose within, especially toward margins and apex" should read: "corolla-lobes about 2.5 mm. long, glabrous without, papillose and glabrous within except for sparse long hairs near sinuses."

#### 4. STRYCHNOS RONDELETIODES Spruce.

VENEZUELA: Amazonas: Cassiquiare, *L. Williams* 15612 (US, Ven). BRAZIL: Amazonas: Basin of Rio Tonantins, *Ducke s. n.* (Jan. 31, 1944); Basin of Rio Negro, *Ducke s. n.* (*H. J. B. R.* 23936) (S).

Local names: Curare de pava (Venezuela).

The Williams specimen is the first record of the species from Venezuela.

#### 4a. STRYCHNOS MACROPHYLLA Barb. Rodr.

BRAZIL: Amazonas: Basin of Rio Negro, *Herb. Est. do Amazonas* 754 (19/7-1941) (M).

Dr. Ducke states on the label: "Manaos, Igarape do Crispo, silva non inundabili, loco humido."

#### 5. STRYCHNOS BARNHARTIANA Krukoff.

BRAZIL: Amazonas: Basin of Rio Tonantins, *Ducke* 1483 (A, F, NY), 1484 (A, F, NY).

The first record of the species from the basin of Rio Tonantins. Ducke states on the label: "fructibus maturis aurantiacis."

#### 7. STRYCHNOS HACHENSIS Karst.

In a private communication to us Dr. A. Dugand of Universidad Nacional, Instituto de Ciencias Naturales, Bogota, Colombia, writes as follows concerning the type locality for the species: "Tomarazon is not near Santa Maria, but about 40 miles due south of Riohacha formerly called Rio de la Hacha or Rio Hacha. The correct spelling is 'Tomarrazón.'"

#### 8. STRYCHNOS TRINERVIS (Vell.) Mart.

BRAZIL: *Frölich s.n.* (S); *Museu Nacional* 41612 (R), 41616 (*Barb. Rodr.* 12) (R), 41642 (*Riedel*, Serra da Guarida) (R). Minas Geraes: *Museu Nacional* 41639 (*Regnell*—III—182; *Caldas*) (R); *Regnell*—III—182 (1834-44) (S). Rio de Janeiro: *Mosén* 2531 (Corcovado) (S); *Glaziou s.n.* (S); *Museu Nacional* 41632 (*Lad. Netto* 102) (R), 41633 (*Netto s.n.*; Sta. Theresa) (R),

41636 (*Lad. Netto s.n.*) (R), 41634 (*Lad. Netto s.n.*, Jurujuba) (R), 41618 (*Glaziou s.n.*; Praia Grande) (R), 41637 (*Freire 596*; Restinga de Crumari) (R), 41644 (*Saldanha & Schwacke s.n.*; Fazenda Sobral, Paraiba do Sul) (R); *Weddell s.n.* (G), 404 (G); *Richard s.n.* (G); *Glaziou 9521* (G); *Freire Allemão s.n.* (G). Parana: *Museu Nacional 41656* (*Schwacke—II—28*; Antonina) (R); *Dusen 10395* (Jaguariahyva, in silvula) (S), 11973 (Antonina, in capueirão) (S). Santa Catarina: *Museu Nacional 41617* (*Fritz Muller 198*; Itajahy) (R).

The collections from Paraná are our first record of the species from that state.

#### 9. *STRYCHNOS PANAMENSIS* Seem.

COLOMBIA: Basin of the Atrato river, Truando, *A. C. V. Schott s.n.* (Dec. 1857).

This plant is cited as "Cinchonaceae #1" in J. Torrey's manuscript copy of Schott's Atrato Plants. "Cinchonaceae #2," collected in the same region and also available to us, has been determined as *Malouetia guatemalensis* (Muell. Arg.) Standley. Torrey's manuscript is deposited in the Library of the New York Botanical Garden.

#### 12. *STRYCHNOS MEDEOLA* Sagot.

SURINAM: Basin of the Coppename River, Raleigh Valley, *Geijskes s.n.* (June 10, 1944). FRENCH GUIANA: *Sagot 398* (P, S). BRAZIL: Para: *Museu Nacional 41658* (*Jobert & Schwacke 868*; Santarem, Serra) (R), 41657 (*Schwacke 145*; Rio Capim, ad Pacoval) (R).

This is the first record of the species from Surinam.

#### 14. *STRYCHNOS TOMENTOSA* Benth.

BRAZIL: Para: Near Catú, *Ducke 1645* (A, F, NY).

This is the first specimen of the species examined by us from the State of Para.

#### 15. *STRYCHNOS DIABOLI* Sandw.

BRAZIL: Amazonas: Basin of Rio Negro, *Ducke s.n.* (2/3-45).

This is the first specimen of the species examined by us from the basin of Rio Negro.

#### 16. *STRYCHNOS JAVARIENSIS* Krukoff.

BRAZIL: Amazonas: Basin of Rio Javary, *Ducke 1770*.

With the collection of *Ducke 1770*, flowering material of *S. javariensis* is now available. The flowers of *S. javariensis* are essentially like those of *S. diaboli*, except that the calyx-lobes (1.5 mm. long), corolla-lobes (1.8 mm. long), and anthers (0.8 mm. long) are somewhat shorter. In *S. diaboli* they are 2 mm., 2.5 mm., and 1.1 mm. long respectively. The two species are best distinguished in their vegetative characters.

In the key to the species in our previous paper (2, p. 262) *S. javariensis* should now be placed next to *S. diaboli* and the key should read as follows:

- Corolla-tube glabrous and papillose without; calyx-lobes about 1 mm. long, glabrous without. . . . . 5. *S. Barnhartiana*.  
 Corolla-tube conspicuously strigose without; calyx-lobes 1.5 or 2 mm. long, pubescent without.  
 Lobes of corolla densely bearded at base within; calyx-lobes densely subsetulose without; pedicels short or none.  
 Leaf blades with secondaries and reticulation faint, 5-15 cm. long, 3-9 cm. broad 15. *S. diaboli*.  
 Leaf blades with prominent rib-like secondaries beneath and deeply impressed reticulation above, 13-19 cm. long, 5-12 cm. broad. . . . . 16. *S. javariensis*.  
 Lobes of corolla glabrous within; calyx-lobes sparsely subsetulose without; pedicels up to 3.5 mm. long. . . . . 6. *S. brachiata*.

# 18. STRYCHNOS JOBERTIANA Baillon.

PERU: Loreto: near Pongo de Manseriche, *Tessmann 4722* (S). BRAZIL: Amazonas: Basin of Rio Solimoes, *Museu Nacional 41651* (*Schwacke s.n.*; Alto Amazonas, Calderão) (R); Basin of Rio Tonantins, *Jobert s.n.* (type coll., P).

The Tessmann specimen is the first record of the species from Peru

# 19. STRYCHNOS PSEUDO-QUINA A. St. Hil.

BRAZIL: Goyaz: *Glaziou 21761* (G, S); *Museu Nacional 41643* (*Ule 464*; "nos cerrados perto de Mossamedes") (R). Matto Grosso: *Museu Nacional 41645* (*Mello s.n.*; Cuiabá) (R). Minas Geraes: *Malme 2411a* (Santa Ana da Chapada) (S); *Lindman A.2515* (Palmeiras, in dumetis campi aprici) (S), *A.3073* (Rio Jocuára, in campis glareosis) (S); *Weddell 1866* (G); *Clausen 135* (G); *Museu Nacional 41629* (*Mello Barreto 5195*; in "cerrado" near Lagoa Santa, munic. Santa Luzia) (R), *41638* (*Regnell—III—179*; Uberaba) (R), *41614* (*Sampaio 6718*; Sta. Luzia, Serra Serra do Cipó) (R), *41635* (*Lad. Netto 104*) (R). São Paulo: *Museu Nacional 41641* (*Regnell—III—179*) (R, S); *Mosén 1474* (Mogy-mirim in campo secco) (S). Rio de Janeiro: *Glaziou 14094* (G).

The Glaziou specimen is the first record of the species from the State of Rio de Janeiro.

# 20. STRYCHNOS XINGUENSIS Krukoff.

According to Ducke (1, p. 14) the cotypes of this species known up to the present time only from the type collection are available at the Botanical Garden at Rio and in Kew Gardens.

# 21. STRYCHNOS AMAZONICA Krukoff.

BRAZIL: Amazonas: Basin of Rio Negro, *Ducke s.n.* (12/4/45), *s.n.* (27/2/45).

# 22. STRYCHNOS PECKII B. L. Robinson.

VENEZUELA: Amazonas: Basin of the Upper Orinoco, island Solitaria, between Tamatama and Esmeralda, *L. Williams 15241*. COLOMBIA: Valle del Cauca: *Cautrecasas 17447*. BRAZIL: *Museu Nacional 41628* (*Luetzelburg 23957*; Rio Papori-Japú-Cachoeira-17/XII-928) (R). Amazonas: Basin of Rio Tonantins, *Ducke s.n.* (Febr. 2, 1944); Basin of Rio Negro, *Ducke s.n.* (July 6, 1943).

Local names: Cúpira (Baniba Indians, Venezuela).

The Williams specimen is the first record from Venezuela, whereas one of the Ducke specimens is the first record of the species from the basin of Rio Tonantins. The Luetzelburg specimen likely is a new record of the species for the State of Ceara or Rio de Janeiro. Outside of the basin of the Amazon in Brazil the species was known up to the present time to occur only in the States of Maranhão and Bahia. We have been unable to



ascertain in what State the Luetzelburg specimen was collected. The Cuatrecasas specimen is the first record of the species from Colombia. It was collected at "costa del Pacifico, Rio Cajambre, silva, 5-80 met. alt."

24. *STRYCHNOS ERICHSONII* Rich. Schomb.

VENEZUELA: Boliver: Basin of the Upper Paragua, *Felix Cardona* 1228. BRITISH GUIANA: *Schomburgk* 981 (G).

Local names: Uruichá (Arekuna, Venezuela).

Cardona's specimen was obtained on Rio Karún, 350 met. (Guayana); it is the first record of the species from Venezuela.

25. *STRYCHNOS GARDNERI* A. DC.

BRAZIL: Ceara: *Museu Nacional* 41620 (*Freire Allemão e M. de Cysneiros* 1006) (R). Goyaz: *Gardner* 3890 (type coll., P). Rio de Janeiro: *Museu Nacional* 41619 (*Glaziov* 12691; Serra do Tingá) (R). São Paulo: *Mosén* 3217 (Santos, ad rivulum umbrosus) (S).

This is the first record of the species from the State of Ceara.

26. *STRYCHNOS PUBIFLORA* Krukoff.

BRAZIL: Minas Geraes: *Museu Nacional* 41630 (*Mello Barreto* 8919; *Jard. Bot. Belo Horizonte* 25907) (R, type coll.).

27. *STRYCHNOS PEDUNCULATA* (A. DC.) Benth.

BRITISH GUIANA: Essequibo: Kamuni creek, *Maguire & Fanshawe* 22875, 22929.

In his recent paper (1, p. 23) Dr. Ducke makes a very interesting observation: "Este espécie coletada em varios lugares da Guiana britânica e na Venezuela não parece habitar Trinidad, apesar de ter por sinônimo *St. trinitensis* Griseb., atribuida à flora daquela ilha. Sandwith e Krukoff relatam que as etiquetas do tipo de *trinitensis* e de um outro espécimen, ambos do herbario do Jardim Botânico de Trinidad, indicam "Caura," como localidade de coleta; êsse nome refere-se evidentemente ao Rio Caura, afluente da margem direita do baixo Orinoco, no Estado de Bolivar, Venezuela."

28. *STRYCHNOS MITSCHERLICHII* Rich. Schomb.

BRITISH GUIANA: Essequibo: Potaro River Gorge, *Maguire & Fanshawe* 23503. SURINAM: Bakhuis mountains, *Geijskes* 1035. BRAZIL: Para: Near Catú, *Ducke s.n.* (Sept. 26, 1944). AMAZONAS: Basin of Rio Tonantins, *Ducke s.n.* (Febr. 17, 1944), 1485 (A, F, NY). COLOMBIA: Valle del Cauca: *Cuatrecasas* 15811, 16617, 17310.

The Cuatrecasas specimens are the first record of the species from Colombia. Cuatrecasas #17310 was collected at "Costa del Pacifico, Rio Cajambre, San Isidro, 5-100 met. alt."; Cuatrecasas #15811—at "Costa del Pacifico, Rio Yurumangui, Veneral, bosques, 5-10 met. alt.," and Cuatrecasas #16617—at "Rio Calima (Región del Chocó), La Trojita, 5-50 met. alt."

29. *STRYCHNOS DARIENENSIS* Seem.

COLOMBIA: Valle del Cauca: *Cuatrecasas* 17673.

The Cuatrecasas specimen is the first record of the species from Colombia. It was collected at "costa del Pacifico, Rio Cajambre, Silva, 5-80 met. alt."

30. *STRYCHNOS GUIANENSIS* (Aubl.) Mart.

VENEZUELA: Amazonas: Basin of the Upper Rio Negro, *L. Williams* 14813, 14883. BRITISH GUIANA: *Schomburgk* s.n. (G). Essequibo: Potaro River Gorge, *Maguire & Fanshawe* 23496. Surinam: Basin of the Coppename River, *Geijskes* 1015, 1032, s.n. (Dec. 17, 1943). FRENCH GUIANA: *Poiteau* s.n. (G); *Leprieur* 243 (G). BRAZIL: Matto Grosso: Juruena, *Museo Nacional* 41615 (*Hoehne* V/909) (R). Para: Basin of Rio Tapajos, *Museo Nacional* 41665 (*Jobert & Schwacke* 867; Santarem, Serra) (R); Basin of Rio Capim, *Museo Nacional* 41660 (*Schwacke* 159; Putirytyá) (R). Amazonas: *Ducke* 1699 (A, F, NY); Basin of Rio Negro, *Ducke* s.n. (2/3-45).

Local names: Cúpira (Baniba Indians, Venezuela).

The Hoehne specimen cited above is the first record of the species from the State of Matto Grosso, whereas *Ducke* 1699 is the first record from the basin of Rio Tonantins, Amazonas.

In his recent paper Dr. Ducke (1, pp. 19 & 20) makes an interesting observation: "A presença de *St. guianensis* em Minas Geraes parece-me carecer de confirmação por novas coleções. *S. oblonga* Gilg, da coleção Glaziou, e, segundo a etiqueta, procedente de Minas, foi reconhecida por Krukoff como co-específica com *S. guianensis*; no entanto, em mais de uma das numerosas plantas distribuídas por Glaziou, as localidades indicadas nas etiquetas foram encontradas errôneas."

*Ducke* s. n. (21/9-45), collected from a giant bush-rope of the forest of terra firma near Catú, Para, is placed by us with the collections that we discuss in remarks in our previous paper (2, p. 297).

31. *STRYCHNOS SUBCORDATA* Spruce.

BRAZIL: Amazonas: *Museu Nacional* 41613 (collector undesignated; Vale do Rio Canumari) (R), 41652 (*Schwacke* s.n.; Manaus) (R), 41653 (*Schwacke* s.n.; Manaus, 1877) (R), 41661 (*Schwacke* s.n.; Manaus, 15/IV-82) (R).

The collector note on *Museu Nacional* 41653 reads: "Urury—uva . . . contendo o principio venenoso agita como o *Strychnos Castelnaci* Wedd. como a diferencia de ser menos eficaz."

32. *STRYCHNOS BICOLOR* Prog.

BRAZIL: São Paulo: *Hemmenдорff* s.n. (Santa Rita do Passa Quatro) (S); *Mosén* 1475 (Mogymirim in campo secco) (S).

33. *STRYCHNOS PANURENSIS* Sprague & Sandw.

COLOMBIA: Chocó: *Cuatrecasas* 16918. Venezuela: Bolivar: *Killip* 37285.

This is the first record of the species from the "Intendencia del Chocó," Colombia, and the State of Boliva, Venezuela.

33a. **Strychnos Duckei** Krukoff and Monachino, sp. nov.

Frutex volubilis magnus; laminis foliorum macroscopice glabris, in siccitate flavescentibus, reticulo venarum utrinque crasso et valde prominente; inflorescentiis elongatis minute hirtellis; lobis calycis ovato-lanceolatis ca. 1.3 mm. longis glabris vel extus sparse hirtellis; lobis corollae intus toto lanatis; antheris ca. 0.8 mm. longis; ovario styloque glabris.

*Macroscopic*: petioles about 3-6 mm. long; blades lanceolate, about 10-11 cm. long, 3.5-4 cm. broad, rounded to obtuse at base, acuminate at apex, somewhat shining on upper surface, duller beneath, drying an olive-ocher yellow with dark petioles, subcoriaceous, 3-plinerved with the inner pair subopposite and diverging at about 4 mm. from base, reticulation coarse and prominent on both surfaces. *Microscopic*: branchlets puberulent with minute adpressed or ascending hairs; petioles very sparsely puberulent with adpressed hairs; blades beneath with inconspicuous atomic dots, universally puberulent with very short adpressed hairs, above occasionally sparsely puberulent on midrib near base, otherwise glabrous.

Inflorescences in elongated thyrses (about 7 cm. long) with nodes of opposite branches along rachis distant, puberulent with pale-brown straight very short adpressed or ascending hairs, bracts lanceolate, sometimes subfoliaceous, pedicels up to 2 mm. long; calyx-lobes ovate-lanceolate, about 1.3 mm. long, acute or acuminate at apex, spreading, glabrous or very sparsely hispidulous without, ciliate; corolla-lobes densely lanate on the whole face within; anthers about 0.8 mm. long; ovary and style glabrous. Fruits not seen.

Type locality: Amazonas (Tabatinga, Marco), Brazil.

Distribution: Known only from the type collection.

Brazil: Amazonas: basin of the Upper Solimoes, *Ducke 1771* (NY, Type).

*S. Duckei* is closely related to *S. panurensis* but easily distinguished from it. In place of "Plant macroscopically glabrous; leaf-blades 5-20 cm. long, etc.," 19th line from bottom of page 295 in our first paper on *Strychnos* (2: 295) substitute the following key:

Plant macroscopically glabrous; leaf-blades with reticulation prominent on both surfaces; infl. generally compound and elongated, many-flowered.

Leaf-blades with fine closely intricate reticulation, the ultimate areolae being microscopic, drying greyish; anthers about 1.6 mm. long; calyx-lobes about 1 mm. long, strongly papillose or grey papillose-puberulent without. . . . . 33. *S. panurensis*.

Leaf-blades with coarse reticulation, the ultimate areolae being rather open, drying yellowish; anthers about 0.8 mm. long; calyx-lobes about 1.3 mm. long, glabrous or sparsely hispidulous with pale-brown hairs without. . . . . 33a. *S. Duckei*.

The collector notes: "Silva non inundabili. Frutex robustus alte scan-



dens floribus albis Jasminum fortiter redolentibus." No tendrils are present in the available material.

34. *STRYCHNOS HIRSUTA* Spruce.

BRAZIL. Amazonas: Basin of Rio Madeira, *Ule* 6105 (G).

The corolla of this species was not previously seen by us. Corolla-lobes are lanate on the lower half within, the upper half is papillose but glabrous.

35. *STRYCHNOS COGENS* Benth.

VENEZUELA: Amazonas: Basin of the Upper Orinoco, between Tamatama and Esmeralda, *L. Williams* 15230 (Ven).

This is the first record of the species from Amazonas, Venezuela.

36. *STRYCHNOS MELINONIANA* BAILLON.

SURINAM: Basin of the Upper Coppename, *Geijskes* 1040.

This is the first record of the species from Surinam.

38. *STRYCHNOS CASTELNAEANA* Wedd.

BRAZIL: Amazonas: Basin of Rio Solimoes: *Museu Nacional* 41664 (*Schwacke* 806; Alto Amazonas, Calderão) (R).

This specimen is of a historical interest. It was collected by Schwacke on his and Jobert's visit to Calderão in Sept. 1877, at which time they witnessed the Curare manufacture by the Tecuna Indians. Schwacke notes on the label: "la base du curare des Indiens Tecunas." The herbarium label of "Herb. J. de Saldanha" attached to this collection reads: "Plantes du Curare des Indiens Tecunas, mission de Calderão, Alto Amazonas:

- |   |                     |
|---|---------------------|
| (1) casca— <i>Strychnos Castelnacii</i> Wedd.       | —"guure" (la base), |
| (2) casca— <i>Anomospermum grandifolium</i> Eichl.* | —"icú,"             |
| (3) caule— <i>Aglaonema</i>                         | —"taja,"            |
| (4) folhas— <i>Petiveria</i>                        | —"yone,"            |
| (5) casca da raiz— <i>Piper</i>                     | —"obue,"            |
| (6) casca da raiz— <i>Artanthe</i>                  | —"aeruma"           |

39. *STRYCHNOS RUBIGINOSA* DC.

BRAZIL: Piauhv: *Museu Nacional* 41662 (*Schwacke* 455; Oeiras) (R). Ceara: *Museu Nacional* 41624 (*Freire Alemão s.n.*) (R). Bahia: *Blanchet* 2918 (type coll, P). PARAHYBA: ? *Museu Nacional* 41625 (*Jayme Vasconcelos s.n.*; Areias) (R). RIO DE JANEIRO: *Glaziov* 4883 (São Christavão, Morro de telegraphos) (type coll. of *S. fulvotomentosa*, S).

\* For a discussion of the botanical identity of this plant, see remarks under *Elissarrhena grandifolia* and *Chondodendron limacifolium* in paper by B. A. Krukoff and H. N. Moldenke entitled "Studies of American Menispermaceae, with Special Reference to species used in Preparation of Arrow-poisons" (*Brittonia* 3: 1-74. 1938). For the other botanical ingredients used by the Tecunas in Curare manufacture see the paper by B. A. Krukoff and A. C. Smith entitled "Notes on the Botanical Components of Curare" (*Bull. Torrey Bot. Club* 64: 401-409. 1937).

The specimens from the States of Ceara and Parahyba are the first record of the species from these two States.

42. *STRYCHNOS PARVIFOLIA* DC.

BRAZIL: Ceara: *Lofgren* 561 (Serra Araripe) (S); *Museu Nacional* 41623 (*Freire Allemão* s.n.) (R), 41621 (*Freire Allemão* e *M. de Cysneiros* 1007) (R), 41622 (*Freire Allemão* e *M. de Cysneiros* 1008) (R). RIO DE JANEIRO: *Museu Nacional* 41627 (*Rangel* s.n.; Estação do Commercio) (R). PARAGUAY: *Rojas* 1536a (*Herb. Corn. Osten* 8404) (S); *Fiebrig* 303 (G).

43. *STRYCHNOS GRAYI* Griseb.

CUBA: Oriente: *Ekman* 1874 (S), 2739 (S), 3406 (S), 6129 (S). HAITI: *Ekman* H. 6757 (Santo Domingo, Cordillera de Bahoruco, prov. de Barahona, Sierra de los Comisarios, between Banane and Gros-Figuier, limestone, 400 m.) (S).

43a. *STRYCHNOS PACHYCARPA* Ducke, Boletim Técnico do Instituto Agrônômico do Norte 3, 1945: 15. 1945.

*Macroscopic*: petioles 5-10 mm. long; blades orbicular-ovate to elliptic or oblong-ovate, 5-9 cm. long, 3.5-6 cm. broad, subcordate to rounded at base, usually abruptly acuminate at apex, shining on upper surface and somewhat duller beneath, membranaceous to chartaceous, 3-5-plinerved with the inner pair subopposite and diverging at 2-11 mm. from base, reticulation moderately prominent on both surfaces. *Microscopic*: branchlets and petioles puberulent with short erect greyish hairs, glabrescent or glabrous; blades beneath sparsely puberulent on principal nerves of essentially glabrous, above sometimes puberulent on midrib, otherwise glabrous.

Inflorescences in paniculate cymes, usually hemispheric and many-flowered, puberulent with short, erect hairs, bracts lanceolate and long-acuminate to ovate, ciliate, otherwise glabrous or sparsely puberulent, peduncles flattened, 7-21 mm. long and about 1 mm. wide, pedicels shorter than calyx; calyx-lobes ovate, about 1 mm. long, acute at apex, ciliate, otherwise glabrous; corolla-tube manifestly longer than calyx, about equal to or slightly longer than corolla-lobes, 1.6-2.3 mm. long, glabrous both without and within (microscopically papillose); corolla-lobes about 2 mm. long, obscurely papillose without, long-bearded near middle within along an upwardly convex arc, otherwise papillose and glabrous; anthers glabrous; ovary and style glabrous. Fruits (ex descrip.) 6-9 cm. in diam., shell 9-10 mm. thick, seeds about 8, with pale-fulvous fibrous (finally easily removable) covering, 3-sided suborbicular with two faces plane and the remaining face rounded, up to 25 mm. long, glaucous-black, rugulose on surface, stony; fruit-pedicels about 10 mm. in diam.

Type locality: Amazonas (near Manaus), Brazil.

Illustrations: Boletim Técnico do Instituto Agrônômico do Norte #3. 1945: pl., fig. 1-5. 1945.

Distribution: Known only from the type collection.



BRAZIL: Amazonas: Basin of Rio Negro, *Ducke* 1403 (type coll., A, F, NY).

*S. pachycarpa* is anomalous in *Breviflorae* because of its relatively long corolla-tube, otherwise in all other features it falls well within the section. The corolla-tube is manifestly longer than the calyx and somewhat longer than the corolla-lobes, but the size of the flower as a whole suggests *Breviflorae*, in which section the species is in harmony in both external and internal floral characters, inflorescence and vegetative habit.

In the key to the species in our previous paper (2, p. 305) *S. pachycarpa* should be placed next to *S. Castelnaeana* under the division "Leaf-blades less than 15 cm. long," etc., and distinguished as follows:

Corolla-tube manifestly longer than calyx, equal to or longer than corolla-lobes, indumentum of greyish puberulence or none ..... 43a. *S. pachycarpa*.  
Corolla-tube shorter than calyx, manifestly shorter than corolla-lobes.

Furthermore, the proper exception introduced by the long corolla-tube of *S. pachycarpa* should be noted in the key to the sections (2, p. 261) and the description of the section *Breviflorae* (2, p. 305).

In the systematic arrangement of the species *S. pachycarpa* belongs with *S. brachistantha* and *S. nigricans*, to which it bears a general resemblance in many respects.

*Ducke* writes the following field description of the plant: "Frutex robustus altissime scandens, cortice trunci crassi in laminulas parvas soluto, inermis, cirrhifer, ramulis cinereo-brunneis dense pallido-lenticellosis, novellis subtetragonis." He also states: "Os frutos atingem até 9 cm. em diâmetro, tamanho alcançado somente pelos de *St. ramentifera*, do Pará, e de *St. hachensis* Karst., do Colômbia; eles cáem durante a estação chuvosa, e os que não se partem pela queda permanecem na chão, inalterados, durante muito tempo. Eles lembram, em forma e côr, laranjas de regular tamanho, ficando, no entanto, enegrecidos depois de algum tempo; a casca lustrosa, lenhoso-suberosa, é dura e espessa, porém quebradiça; a polpa branca é doce e será sem dúvida comida por animais da mata, mas aparentemente só é aproveitada nos frutos quebrados na ocasião da queda. Notáveis são as sementes, grosseiramente fibrosas, que diferem muito das sementes sedosas ou felpudas das outras espécies que pude obter. A planta, até agora só observada num unico exemplar, na mata das terras altas ao Nordeste de Manaos, é um cipó robusto, ramificado nas copas de varias árvores altas."

#### 45. STRYCHNOS NIGRICANS Prog.

BRAZIL: cult. Museu Paraense, Belem, *Ducke* 1613 (A, F, NY). Amazonas: Basin of Rio Negro, *Ducke* s.n. (12/4-45). Minas Geraes: *Esc. Sup. Agr. & Vet.* 1515; *Museu Nacional* 41650 (*Schwacke* s.n., Serra da Cayana) (R).

This is the first record of the species from the State of Minas Geraes. *Ducke* states on the label (*Ducke* 1613): "Belem, Museu Paraense culta,



a J. Huber e medio Rio Purus introducta. Frutex alte scandens fructibus aurantiacis."

48. *STRYCHNOS TARAPOTENSIS* Sprague & Sandw.

COLOMBIA: Cundinamarca: between Tocaima and Pubenza, ? Killip, Dugand & Jaramillo 39,309 (US).

The specimen is sterile and we are unable to identify it with any certainty.

49. *STRYCHNOS BRASILIENSIS* (Spreng.) Mart.

BRAZIL: Minas Geraes: *Regnell III-183* (29/10-1847) (S), *III-183* (Pedra Branca, 1854-1858) (S), *III-183* (15/1-1864) (S), *II-137* (10/11-1846) (S), *II-137* (30/4-1869) (S); *Mosén 623* (Caldas, in campo umbroso) (S), *4251* (S); *Widgren s.n.* (S), *s.n.* (1845) (type coll. of *S. macroacanthos*, S); *Weddell 881* (G); *Museu Nacional 41631* (Mello Barreto 11022, Poços de Caldas—Cascata das Antas) (R), *41640* (*Regnell III-183*, Caldas) (R). RIO DE JANEIRO: *Glaziou 6047* (Serra dos Órgãos, Therezapolis) (S); *Museu Nacional 41647* (*Schwacke s.n.*, Fazenda Sobral do Dr. Viriato de Medeiros, Paraiba do Sul) (R). São Paulo: *Mosén 1472* (Serra de Caracol) (S), *1473* (S); *Heiner s.n.* (Campinas; 1904-1906) (S), *258* (Campinas, prope Ponte Preta) (S). PARANÁ: *Dusen s.n.* (Itararé, in silvula; 7/11-1910) (S), *s.n.* (Therezina, in capueira; 20/1-1911) (S), *1252a* (Villa Velha, in silvula; 4/11-1914) (S), *8010* (Capão Grande, in silvula) (S), *8784* (Jacarehy, in silva primaeva) (S), *11245* (Therezina, in capueira) (S); *Jöhnsson 818a* (Jacarehy, in silva primaeva) (S); *Museu Nacional 41655* (*Schwacke 11-23*, Antonina) (R). SANTA CATARINA: *Museu Nacional 41626* (*Hetschko* Col. IV, Blumenau) (R), *41648* (*Schwacke s.n.*, Joinville) (R). RIO GRANDE DO SUL: *Lindman A. 1487* (Santa Maria in silvulis dumetisque) (S); *Malme s.n.* (17/4-1893) (S), *474* (Porto Alegre, pr. Menino Dues) (S). PARAGUAY: *Hassler 9645* (G); *Balansa 2049* (G), *2050* (G); *Balansa 2049* (Villa Rica) (S). ARGENTINA: Misiones: Posadas, *Ekman 1393* (S), *1442* (S).

The specimen *Glaziou 6047* is cited by Gilg under *S. Sellowiana* Gilg in Bot. Jahrb. 25, Beibl. 60: 41. 1898.

LITERATURE CITED

1. DUCKE, A. O gênero *Strychnos* L. na Amazonia Brasileira, Boletim Técnico do Instituto Agromômico do Norte # 3. 1945: 1-23. 1945.
2. KRUKOFF, B. A. & J. MONACHINO. The American Species of *Strychnos*. *Brittonia* 4: 248-322. 1942.
3. KRUKOFF, B. A. & J. MONACHINO. Supplementary Notes on the American Species of *Strychnos*. *Brittonia* 5: 21-24. 1943.